18 OCT 1972

UNITED STATES OF AMERICA
GENERAL SERVICES ADMINISTRATION
National Archives and Records Service
Washington, D.C. 20408

October 16, 1972

STATINTL

[redacted]
Central Intelligence Agency
Records Administration Officer
Stop 64

STATINTL

Dear [redacted]

Enclosed is a copy of NBS Report No. 10843, Development of Specifications for File Folders for Storage of Permanent Records and Report No. 10844, Development of Specifications for Bond and Ledger Papers for Permanent Records.

Please note that these reports contain proposed specifications for file folders and bond and ledger paper. I am sure these will be of interest to you.

Sincerely,

James L. Gear
JAMES L. GEAR
Acting Director
Technical Services Division

Enclosure

Keep Freedom in Your Future With U.S. Savings Bonds

MEMORANDUM FOR: [redacted]

STATINTL

Attached is our copy of the NBS report on the continuing development of specifications for Archival Record Materials, especially paper. As you know, this project is financially supported by several Federal agencies (CIA included) and private industry.

STATINTL

[redacted] called a couple of months ago inquiring as to the status of this study.

If you wish to retain this copy I shall request another.

STATINTL

STATINTL

[redacted]

[redacted]

8 September 197

(DATE)

FORM NO. 101 REPLACES FORM 10-101
1 AUG 54 WHICH MAY BE USED

30 August

FILE.

UNITED STATES OF AMERICA
GENERAL SERVICES ADMINISTRATION

National Archives and Records Service
Washington, D.C. 20408

72-4871

August 28, 1972

STATINTL

[redacted]
Central Intelligence Agency
Records Administration Officer
Stop 64

STATINTL

[redacted]

Attached you will find NBS Semiannual Report No. 18887 covering work on paper research for the period January 1, 1972 through June 30, 1972.

The information in Section 3.1, page 3 and 4 of the report is most significant, and is extremely important in relation to stability and preservation of paper.

Sincerely,

James L. Gear

JAMES L. GEAR
Acting Director, Technical Services Division

Keep Freedom in Your Future With U.S. Savings Bonds

NATIONAL BUREAU OF STANDARDS REPORT

10 887

DEVELOPMENT OF SPECIFICATIONS
FOR
ARCHIVAL RECORD MATERIALS

Semiannual Report

to

National Archives and Records Service
General Services Administration

January 1 - June 30, 1972

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] was established by an act of Congress March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau consists of the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Computer Sciences and Technology, and the Office for Information Programs.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of a Center for Radiation Research, an Office of Measurement Services and the following divisions:

> Applied Mathematics—Electricity—Heat—Mechanics—Optical Physics—Linac Radiation[2]—Nuclear Radiation[2]—Applied Radiation[2]—Quantum Electronics[3]—Electromagnetics[3]—Time and Frequency[3]—Laboratory Astrophysics[3]—Cryogenics[3].

THE INSTITUTE FOR MATERIALS RESEARCH conducts materials research leading to improved methods of measurement, standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government agencies; and develops, produces, and distributes standard reference materials. The Institute consists of the Office of Standard Reference Materials and the following divisions:

> Analytical Chemistry—Polymers—Metallurgy—Inorganic Materials—Reactor Radiation—Physical Chemistry.

THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations leading to the development of technological standards (including mandatory safety standards), codes and methods of test; and provides technical advice and services to Government agencies upon request. The Institute also monitors NBS engineering standards activities and provides liaison between NBS and national and international engineering standards bodies. The Institute consists of the following technical divisions and offices:

> Engineering Standards Services—Weights and Measures—Flammable Fabrics—Invention and Innovation—Vehicle Systems Research—Product Evaluation Technology—Building Research—Electronic Technology—Technical Analysis—Measurement Engineering.

THE CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides technical services designed to aid Government agencies in improving cost effectiveness in the conduct of their programs through the selection, acquisition, and effective utilization of automatic data processing equipment; and serves as the principal focus within the executive branch for the development of Federal standards for automatic data processing equipment, techniques, and computer languages. The Center consists of the following offices and divisions:

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THE OFFICE FOR INFORMATION PROGRAMS promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal Government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System; provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world, and directs the public information activities of the Bureau. The Office consists of the following organizational units:

> Office of Standard Reference Data—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Part of the Center for Radiation Research.
[3] Located at Boulder, Colorado 80302.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT		NBS REPORT
4110442	June 30, 1972	10 887

DEVELOPMENT OF SPECIFICATIONS FOR ARCHIVAL RECORD MATERIALS

William K. Wilson and Edwin J. Parks
Paper Evaluation Section
Product Evaluation Technology Division
Institute for Applied Technology

Semiannual Report
to
National Archives and Records Service
General Services Administration

January 1 – June 30, 1972

NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

DEVELOPMENT OF SPECIFICATIONS FOR ARCHIVAL RECORD MATERIALS

Prepared By

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William K. Wilson

WILLIAM K. WILSON, Chief
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REVIEWED BY:

J. Thad Sterling

J. THAD STERLING
Report Review Chairman

APPROVED BY:

Melvin R. Meyerson

MELVIN R. MEYERSON, Chief
Product Evaluation Technology Division

April 28, 1972

CONTENTS

Approved For Release 2002/05/06 : CIA-RDP74-00390R000300290001-3

1. BACKGROUND

In response to a request by National Archives and Records Service, the National Bureau of Standards is developing information on the variables associated with the stability of archival record materials, especially paper. Since the inception of the project, several U.S. Government agencies and the Society of American Archivists have joined in sponsorship of the project through National Archives and Records Service.

Many record materials in repositories in the Federal Government and throughout the United States are in very bad physical condition. If proper specifications were available for materials that are designed to be used for permanent records, future problems and the cost of repairing the mistakes of the past would be greatly minimized.

The major effort has been directed toward manifold, bond and ledger papers, and especially the development of test methods that may be used in the preparation of specifications. In addition, there is now an urgent need to establish permanence criteria for papers that can be used in office copying machines. Other materials that will merit attention are inks, typewriter ribbons, carbon paper, laminating film, mending tape, and binding materials.

2. OBJECTIVES

The objectives of this program are as follows: (1) the development of information on the stability of paper and other record materials, (2) the development of test methods for the evaluation of the stability of paper and other record materials, (3) the development of specifications for these materials.

3. WORK IN PROGRESS

3.1 Laboratory Aging

The work on laboratory aging has been continued on a lower scale than in recent years. The laboratory aging performed during the past six months has primarily concerned the effects of aluminum in reducing stability. As indicated in the previous progress reports, this metal appears to have the same effect as protonic acids.

All aging was carried out at 90°C. Other variables in the aging environment included: (1) a mixture of 30 percent oxygen and 70 percent nitrogen at 50 percent relative humidity, and (2) air at 0 percent relative humidity. Using 30 percent oxygen and 50 percent relative humidity at 90°C results in an atmosphere containing about 20 percent oxygen, the same amount as in dry air.

Paper that is deashed, treated with aluminum sulfate, and then washed extensively retains a small amount of the metal, probably bound to carboxyl groups that are introduced in bleaching. The effect of alum treatment as indicated in the last semiannual report (10 696) is a pronounced destabilization of the paper, qualitatively different when aging occurs in dry gases than in humid gases, but strikingly evident in both. New investigations have involved the aging

of alum-treated paper made alkaline by codepositing calcium carbonate with the handsheet when it is formed. The aluminum is nearly all retained.

While the data have not been fully evaluated, they show conclusively that paper containing aluminum is not necessarily stabilized by buffering at the relatively high pH level of 8.7. In contrast, paper of similar stock but untreated with alum or buffer had a pH of about 6.0 and was found to be much more stable than the alum-treated, buffered paper. This information opens up very important practical and theoretical questions. If alkaline paper can be unstable, a pH test of stability cannot be fully trusted. The instability of acid paper cannot be attributed with complete confidence to the chemical activity of hydrogen ions, since they can be neutralized and yet instability persists. A possible explanation is that hydrogen ions and aluminum cations both belong to a class of acids (Lewis acids), some of which can be harmful to paper. If so, there may well be other metals that are equally harmful, or more so. A qualitative test for the presence of various metals may eventually be indicated for permanent papers, whatever their pH.

The wide differences between the aging processes which occur in dry and humid gases indicate that different chemical

reactions may be involved when water is available. There is a serious need to evaluate the effect of moisture concentrations in the aging environment on the course of aging reactions. In our work, temperatures and relative humidities have been controlled very closely. This is desirable in a research experiment, but there is some indication in the literature that nearly the same aging processes are obtained at a given temperature over a wide range of relative humidities. If this is so, aging conditions including moisture in the atmosphere but allowing some leeway on relative humidities might be permitted in an accelerated aging specification.

3.2 Specifications for Manifold Paper for Permanent Records

Interim specifications for manifold papers for permanent records have been balloted by ASTM D-6, Paper. About 65 percent of the membership voted, and only two negative ballots were received. Although the specifications essentially have been approved, ASTM regulations require that negative ballots be resolved. If this can be done on the basis of editorial change, little delay should result. However, if the negatives cannot be resolved on the basis of editorial change, it will be necessary to reballot the Specifications Subcommittee of D-6 as well as the main committee. The latter procedure might require several months.

3.3 Specifications for Bond and Ledger Papers for Permanent Records

In NBS Report 10 446, Semiannual Report to National Archives and Records Service, dated June 30, 1971, it was reported that several samples of writing papers had been tested and the preliminary report had been submitted informally to the Paper Research Committee of the Society of American Archivists. It was agreed that two or three basis weights should be specified. Through a review of the papers that are available from the Joint Committee on Printing, and through conversations with several suppliers of bond and ledger papers, it appeared desirable to have three weights of bond papers, namely, 16, 20, and 24 pound (17 x 22, 500) and two weights of ledger paper, namely, 24 and 32 pound (17 x 22, 500). About ninety-three samples of these weights were collected and have been tested. A report has been written, including interim specifications based on the data for these weights of bond and ledger papers. Copies of the report have been mailed to the various suppliers to give them an opportunity for comment before preparation of a final draft of the specifications.

3.4 Specifications for File Folders for Permanent Records

A report has been prepared on the specifications for file folders for permanent records. This report was based on studies of file folder stocks of 0.008, 0.0095, 0.011, and 0.014 inch, nominal thicknesses which were obtained from the Government Printing Office and commercial sources. Copies of this report also have been mailed to the suppliers for comment and criticism before the preparation of a final draft.

3.5 Specifications for Office Copy Papers

In response to our request, the manufacturer of office copying machines using the transfer electrostatic process has kindly provided a copy of the specification limits suggested for papers intended for use in their office copying machines. These specifications have a bearing on the ability of the paper to accept an image and to be transported properly through the machines.

The recommended tests were applied to bond and ledger papers of 16, 20, and 24 pound (17 x 22, 500) weights. The results indicate that very few bond papers would be smooth enough to be used in the machines, although a majority do meet the other suggested criteria. Apparently, rough papers do not take an image very well. However, a majority of the 24 pound ledger papers do meet all of the requirements, including smoothness.

Because the smoothness requirement for this copying paper is relatively tight, it would not be desirable to include a specification of suitability for use in these machines as an integral part of the bond paper specifications; i.e., set a specification limit that all bond papers would have to meet. As there may be continuous changes in the technology of office copying methods, it is also doubtful that we should undertake to set specification limits on variables affecting transport properties.

If a paper is to be used in office copying machines, an alternative might be to give responsibility to the supplier to establish that the material is suitable for those machines. Paper permanence requirements (based on accelerated aging or pH) and perhaps strength criteria could be specified.

Some thought must be given to the policy to be taken with respect to the stability of images produced by copies from office copying machines, carbon paper, fountain pen ink, ball point ink, and typewriter ribbon. Should images produced by the different means be treated as separate entities, or should they be treated as a group? The former approach builds specifications around things as they are. If images produced by various means are treated as a group,

one or more types of images might be treated unfairly. However, this would allow specifications to be written on a performance basis. It is suggested that we cross this bridge after we have obtained enough data to be able to make an intelligent decision.

3.6 Cooperation with the Institute of Paper Chemistry

Through the courtesy of Dr. Wilmer Wink of the Institute of Paper Chemistry, samples of 44 book papers, along with their pH values, were supplied, and differential thermal analysis data were obtained on these samples as mentioned in NBS Report 10 696. These data have been sent to the Institute of Paper Chemistry where the DTA data may be correlated with aging data. It is hoped that a brief report on this phase of the work will become available.

3.7 Cooperation with the Keuffel and Esser Company

A representative of the Keuffel and Esser Company, Mrs. Catherine Feasenmyer, provided us last summer with a collection of tracing papers dating back to 1940. These papers had been tested at that time and at intervals since that time. Mrs. Feasenmyer was willing to test the papers again and give them to us for whatever testing we would like

to do. We have performed differential thermal analysis and pH on these papers. As soon as we receive data on her most recent tests, a report will be written and submitted to the sponsors. This is a very important piece of work as it will be possible to compare natural aging with pH data and with differential thermal analysis data.

4. SPECIAL METHODS OF EVALUATION

In NBS Report 10 446, several special methods of evaluation were discussed in some detail. These methods have been discussed extensively in the last three reports on the aging of handsheets, 10 627, 10 628, and 10 687. These special methods of evaluation have permitted us to learn more about the mechanisms of the aging of paper and differences that arise in dry and humid atmospheres than any other possible approach.

5. PLANS FOR USE OF PL-480 FUNDS

The U.S. Government supplies foreign currency in the course of its overseas operation. The largest source of foreign currency is from the sale of surplus farm commodities within the limits established by Title 1 of Public Law 480. These currencies are kept in Treasury Department accounts and are available to Government agencies to finance overseas activities.

An approach was made to one country, through proper channels, about a year ago soliciting a proposal for research on stability of paper. Although correspondence with the Scientific Attache in the country involved indicates substantial progress, nothing has happened in the last several months.

6. STATUS OF REPORTS AND MANUSCRIPTS

6.1 Reports

(1) Development of Acidity During the Accelerated Aging of Paper. In preparation. Some further laboratory work on this report may be needed.

(2) Specifications for Bond and Ledger Papers for Permanent Records. The laboratory work has been completed and a report has been submitted to the suppliers for review.

(3) Specifications for File Folders for Permanent Records. Laboratory work on this has been completed and a report has been submitted to the suppliers for review.

(4) Differential Thermal Analysis of Book Papers, with IPC. Laboratory work is completed. Preparation of a report must await further contact with IPC.

(5) Evaluation of the Stability of Tracing Papers with Keuffel and Esser. Laboratory work is completed at NBS. The preparation of a report must await contact with Keuffel and Esser.

(6) The Accelerated Aging of Al-Treated Paper Buffered at High pH. Work is now in progress.

6.2 Manuscripts

(1) Evaluation of the Stability of Manifold Papers, by W. K. Wilson and R. L. Hebert. Published in Tappi 55 (7) 1103 (1972).

(2) Thermal Analysis of Ion Exchange Reaction Products of Wood Pulps with Calcium and Aluminum Cations, by E. J. Parks and R. L. Hebert. Accepted for publication by Tappi.

6.3 Other

Dr. R. J. McCarter of the Flammable Fabrics Section presented a paper entitled, The Pyrolysis and Flammability of Slightly Modified Cellulose, by R. J. McCarter, E. J. Parks, and E. L. Graminski at the April 1972 meeting of the American Chemical Society in Boston, Massachusetts. This was based partly on work performed in collaboration with our section.

7. PLANS FOR THE PERIOD, JULY 1, 1972-JUNE 30, 1973

(1) A report on the cooperative work with the Institute of Paper Chemistry should be available.

(2) A report on the cooperative work with Keuffel and Esser should be available.

(3) A deashed paper will be buffered with calcium carbonate to compare its stability in the absence of aluminum to that of buffered alum-treated paper.

(4) A paper prepared in 1938, that contains alum and $CaCO_3$ will be aged in air at 90°C and 50 percent and 0 percent relative humidity.

(5) An alum-treated paper will be aged at 90°C and 25 percent relative humidity to check the importance of relative humidity.

(6) Plans are being made to test a group of naturally aged papers in order to be able to select, with some degree of confidence, experimental conditions for the accelerated aging of paper. Fortunately, some papers made in the NBS paper mill are available.

(7) Work on interim specifications for manifold papers, bond and ledger papers, and file folders will be continued.

(8) Recent discoveries on aging processes suggest that an extensive review of the literature at this time might throw new light on old data and obviate a great deal of experimental work. It is planned to report on this during the next six or twelve months.

Work on the above tasks will proceed as dictated by the needs of the program, and time may not permit work on all of them. Items 6 and 7 are especially important.

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NATIONAL BUREAU OF STANDARDS REPORT

10 844

DEVELOPMENT OF SPECIFICATIONS FOR BOND AND LEDGER PAPERS FOR PERMANENT RECORDS

Technical Report

to

National Archives and Records Service
General Services Administration

NBS

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] was established by an act of Congress March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau consists of the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Computer Sciences and Technology, and the Office for Information Programs.

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[3] Located at Boulder, Colorado 80302.
[4] Part of the Center for Building Technology.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT		NBS REPORT
4110442	May 1, 1972	10 844

DEVELOPMENT OF SPECIFICATIONS FOR BOND AND LEDGER PAPERS FOR PERMANENT RECORDS

E. J. Parks, R. L. Hebert, and G. H. Limparis
Paper Evaluation Section
Product Evaluation Technology Division
Institute for Applied Technology

Technical Report
to
National Archives and Records Service
General Services Administration

NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

DEVELOPMENT OF SPECIFICATIONS FOR BOND AND LEDGER PAPERS FOR PERMANENT RECORDS

Prepared By

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APPROVED BY:

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MELVIN R. MEYERSON, Chief
Product Evaluation Technology Division

CONTENTS

FOREWORD

In response to a request by National Archives and Records Service, the National Bureau of Standards is developing information on the variables associated with the stability of archival record materials, especially paper. Since the inception of the project, several U.S. Government agencies and the Society of American Archivists have joined in sponsorship of the project through National Archives and Records Service.

Although the present effort is directed toward paper, and especially the development of test methods that may be used in the preparation of specifications, other materials that will merit attention are quick copy reproductions from office copying machines, inks, typewriter ribbons, carbon paper, laminating film, mending tape and binding materials.

The objectives of this program are as follows: (1) the development of information on the stability of paper and other record materials, (2) the development of test methods for the evaluation of the stability of paper and other record materials, and (3) the development of specifications for these materials.

The principal need of the archivist and librarian is for specifications for the papers on which records are written. In order to achieve this, as much technical information as possible must be developed on the relative stability of various chemical structures that affect the physical properties of paper. Specifications should include tests that will predict permanence and that could be run in the usual control laboratory and should include an accelerated aging method.

In order to develop an accelerated aging method, it is necessary to age several papers in the laboratory, giving particular attention to variables such as the composition of the paper, temperature, relative humidity, open or closed aging system, and many others. Time does not permit the study of all possible variables, but a study of selected variables allows one to make some generalizations about the parameters that are important in the stability of paper.

As the development of the information necessary to writing an accelerated aging method for estimating the relative stability of papers is long-range research, it is desirable to prepare interim specifications for various papers pending the availability of more complete data. The stability of papers can be predicted, on a relative basis, from the pH, or acidity, values of the papers. The correlation between pH and stability is not a perfect one as stability depends, in addition to pH, on the chemical composition of the cellulose as well as additives that are introduced during the papermaking process.

Interim specifications, based on pH requirements, for manifold papers have been written and are going through channels in Committee D-6, Paper, of the American Society for Testing and Materials (ASTM). Work has been completed on specifications for bond and ledger papers and for file folders.

This report contains interim specifications for bond and ledger papers and the data used in developing these specifications. The specifications are based on minimum pH requirements and minimum strength requirements. The latter are derived from data obtained from testing over 90 samples of paper obtained from commercial sources.

WILLIAM K. WILSON

1. INTRODUCTION

This report contains data on tests performed on 93 samples of bond, ledger, and parchment papers. A variety of samples was selected for testing in order to provide a background of information on available papers of this type, particularly those of interest to archivists and librarians. Interim specifications for several weights of bond and ledger paper have been prepared and are included in the appendix. The test data obtained on parchment papers are included for information, but no specifications covering parchment papers were prepared.

Approved For Release 2002/05/06 : CIA-RDP74-00390R000300290001-3

1. INTRODUCTION

This report contains data on tests performed on 93 samples of bond, ledger, and parchment papers. A variety of samples was selected for testing in order to provide a background of information on available papers of this type, particularly those of interest to archivists and librarians. Interim specifications for several weights of bond and ledger paper have been prepared and are included in the appendix. The test data obtained on parchment papers are included for information, but no specifications covering parchment papers were prepared.

2. SAMPLES

Ninety-three samples of bond, ledger, and parchment papers, which included 16 samples obtained from the Government Printing Office and 77 samples obtained from 10 manufacturers, were tested in order to develop information necessary for writing interim specifications for permanent record papers. The samples ranged in fiber content from 100 percent wood pulp to 100 percent rag. The nominal basis weights included 16, 20, 24, 32, and 44 pound papers (17" x 22", 500).

3. TEST METHODS

The methods of test used in this investigation are described in the collected "Standard and Suggested Methods" of TAPPI (Testing Methods and Recommended Practices, Technical Association of the Pulp and Paper Industry, 1 Dunwoody Park, Atlanta, Georgia 30341).

3.1 Thickness

Thickness was determined by TAPPI Method T 411.

3.2 Weight per Unit Area

Weight per unit area was determined by TAPPI Method T 410 and reported both in g/m^2 and pounds per 500 sheets, 17 x 22 inches.

3.3 Opacity

Opacity was determined by TAPPI Method T 425. Opacity is a function of the amount of light that can pass through a sheet of paper and is determined as the ratio of the diffuse reflectance of a specimen backed with black to the diffuse reflectance of the same specimen backed with a white body. For TAPPI opacity, the white body reflectance is 0.89. Opacities are reported to the nearest 0.1 percent as the ratios of the mean values of 10 measurements of these reflectances.

3.4 Brightness

Brightness was measured according to TAPPI Method T 452. It is a measure of blue reflectance at an effective wavelength of 457 nm. Brightness measurements were made on an instrument that illuminates the specimen at 45° (in essentially only one azimuthal direction) and views the incident light at 90°. Since the measured values of brightness differed in the machine and cross directions of the paper, measurements are reported for both directions. The measured values are consistently lower with the incident beam parallel to the machine direction.

3.5 Folding Endurance

The MIT folding endurance, determined according to TAPPI Method T 423, represents the number of times a paper can be folded under controlled tension before it breaks. A tension of 1 kg was used in these tests. Folding endurance is generally considered to be a function of durability, although this is not necessarily true.

3.6 Bursting Strength

Bursting strength was determined according to TAPPI Method T 403. It is considered to be a function of the strength of paper in the stronger direction.

3.7 Internal Tearing Resistance

Internal tearing resistance was measured according to TAPPI Method T 414. It is the force required to continue a tear after an initial cut has been made.

3.8 pH

pH was determined by both hot and cold extraction methods, T 435 and T 509, respectively.

3.9 Number of Replicate Tests

pH determinations were performed in duplicate. All other tests were performed on at least ten specimens of every sample. The individual figures in Tables 1-6 represent averages of all of the results obtained on each sample.

4. RESULTS AND DISCUSSION

4.1 Results

Tables 1-3 contain data on bond papers with nominal basis weights of 16, 20, and 24 pounds (17 x 22, 500). Table 4 includes 24 pound ledger paper and Table 5 includes 32 and 44 pound ledger paper. Data on four weights of parchment paper are given in Table 6. These samples include papers of zero to 100 percent rag content, as reported by the suppliers, and a number of chemical wood (CW) papers.

Table 7 is a guide list indicating which of the samples are GPO papers and the JCP specifications for them.

Figures 1-4 show least-square slopes of bursting strength, internal tearing resistance, folding endurance, and opacity, as a function of weight per unit area (g/m^2). The coefficients of correlation are given in Table 8.

4.2 Discussion

4.2.1 Effects of weight and rag content on folding endurance, tearing resistance, and bursting strength

The effects of rag content in the 25-100 percent range and effects of weight per unit area on strength and folding endurance are indicated in Tables 9-11, with papers of different weight and similar rag content and papers of similar weight but different rag content. Each entered value represents an average of all the readings taken on a given paper.

In all cases studied, the bursting strength and tearing resistance increased with weight, tear being somewhat more dependent on weight. This is indicated in Figures 1 and 2. There is a qualitative similarity in weight dependence and a notably higher coefficient of correlation for tear than for bursting strength. Consequently, it is suggested that the bursting test could well be dispensed with for all of the samples, if a specification for tearing strength is given.

Folding endurance is not very dependent on weight, as evidenced in the nearly random scatter of points in Figure 3. The folding endurance of papers having 100 percent rag content tends to be relatively high as indicated in Table 9. However, samples having less than 100 percent rag show no correlation between folding endurance and rag content.

Tearing strength and bursting strength do not appear to be affected by rag content, as indicated by the data in Table 9.

4.2.2 pH

It is generally believed that acidity can promote the degradation of paper and that pH, consequently, is a criterion of permanence. The JCP specifications require that "permanent" papers have a minimum pH of 5.5, and a recent suggested interim specification for manifold papers intended for permanent records lists three levels of permanence with pH levels of 5.5, 6.5-7.5, and 7.5-9.5 (NBS Technical Report 10 518, to National Archives, Interim Specifications for Manifold Papers for Permanent Records, June 30, 1971). About a third of the papers included in this study have a pH of 5.5 or higher, and representative samples of the two higher pH categories are included.

4.2.3 Brightness and Opacity

The data on brightness show a greater directional effect than one would expect. The recommended method specifies testing paper in the machine direction. This procedure should be satisfactory, as the brightness of these samples is usually lower in the machine than the cross direction, and a minimum brightness is specified.

Figure 4 indicates that opacity increases with weight per unit area, although there is a great deal of scatter about the least squares slope. Opaque fillers would increase opacity to an extent out of proportion with the increase in weight, but it is reasonable to peg minimum opacity requirements to weight per unit area.

4.2.4 Writing and Erasing Properties

An attempt was made to assess the writing quality of papers simply by writing letters and numbers on each paper and visually checking their clarity. A one percent aqueous solution of C.I. acid red dye was used, as specified in the JCP methods, and a No. 67 penpoint. This method is open to criticism, as the quality of the writing depends on the pen and the writer as well as the ink, and the evaluation of results is highly subjective. All of the papers tested in this study appeared to pass the writing test. Another observer might not reach this conclusion.

Erasing quality also may be an important property for specific papers, but the available methods do not seem to be appropriate for the present study, and this property was not evaluated. Many variables must be considered in the design of a meaningful erasure test--e.g., the ease and completeness of erasure, the type and the condition of the typewriter, the ribbon, and perhaps even the relative humidity of the room, the type of eraser, and the pressure exerted on it. It is suggested that if erasure properties are likely to be important, they should be a subject of negotiation.

5. SUMMARY AND SUGGESTIONS

1) The samples included in this testing program encompass the bond and ledger papers that might reasonably be expected to serve the purposes of archivists and librarians.

2) It may be necessary to make some compromises with respect to properties of papers that are considered desirable by archivists and librarians. For example, from the data presented in Table 1, it would not be feasible to specify an unfilled paper with a minimum opacity of 80 and a basis weight of 50 grams per square meter. High tearing strength, high folding endurance, and low basis weight would not be compatible.

3) About one third of the papers have a pH of 5.5, or higher, hot extraction, Presumably, there would be no difficulty in producing papers with a pH of 5.5 or higher.

4) Papers having a rag content of 100 percent tend to have a high folding endurance, but no correlation of folding endurance and rag content is evident if the rag content is less than 100 percent.

5) Interim specifications, based on the data presented in this report, are included in the appendix.

6. ACKNOWLEDGMENT

The assistance of the manufacturers who supplied samples for evaluation and who, for obvious reasons, must remain unnamed, is gratefully acknowledged.

APPENDIX-- PROPOSED NEW STANDARD SPECIFICATIONS FOR BOND AND LEDGER PAPERS FOR PERMANENT RECORDS

1. SCOPE

This specification covers bond and ledger papers used in the preparation of permanent or semi-permanent copies of records and documents. Permanence has been shown to be at least an approximate function of pH, and three pH levels, reflecting three levels of permanence, are specified.

2. CLASSIFICATION

2.1 Grades. Three grades are specified. The only differences among the three grades are the pH requirements and the type of filler or sizing to achieve this. For situations where the copies will be handled frequently, the grade should be described as "high referral." A folding endurance of 500 is required for this category, and the purchaser might wish to specify all or part new cotton or linen. This may be unused industrial waste.

2.2 Grade A. Paper with alkaline filler. The paper shall contain an alkaline <u>filler</u> of calcium and/or magnesium carbonate. The minimum shall be 2 percent, calculated to calcium carbonate, based on the oven dry weight of the finished paper. The pH shall fall within the range 7.5-9.5, hot extraction.

2.3 Grade B. Neutral-sized paper. The paper shall be neutral-sized, and the pH shall fall within the range 6.5-8.5, hot extraction.

2.4 Grade C. Paper with minimum pH value. The paper shall have a minimum pH of 5.5, hot extraction.

3. REQUIREMENTS

3.1 Paper Stock. Free from unbleached or ground wood pulp. The stock shall be fully bleached wood pulp, new cotton or linen pulp, or a mixture, as specified at the time of purchase.

3.2 Acidity (pH). See 2.1.

3.3 Sizing. If a sizing requirement is necessary, the sizing shall be sufficient to prevent feathering when the paper is written on with aqueous inks.

3.4 Weight per unit area. The average weight in grams per square meter shall be within the range of 57-63, 71-79, 85-95, and 114-126 as specified, but the variation of test unit averages within a shipment (or lot) shall be not more than 5 percent above or below the lot sample average value. These are the nominal 16, 20, 24, and 32 lb. (17 x 22, 500) papers, respectively, the metric equivalents of which are 60, 75, 90, and 120 grams per square meter.

3.5 Thickness. The average thickness in mils (0.001 inch) and millimeters (mm) shall be within the ranges tabulated below for papers of four different weights. The variation of test unit averages within a shipment (or lot) shall be not more than 5 percent above or below the average value.

Weight per Unit Area		Thickness			
		Bond		Ledger	
g/m^2	lbs (17x22,500)	mm	mils	mm	mils
60	16	.086-.096	3.4-3.8	--	--
75	20	.105-.115	4.3-4.7	--	--
90	24	.130-.145	5.1-5.7	.112-.122	4.4-4.8
120	32	--	--	.140-.165	5.5-6.5

3.6 Folding Endurance, MIT double folds at 1 kg tension. For "high referral" papers, the value shall be not less than 500 for the average of the two directions. Otherwise, there is no folding endurance requirement.

3.7 Tearing Resistance. The minimum average in each direction shall be not less than the following for different weights of bond paper.

Basis Weight		Tearing Resistance gms	
g/m^2	lbs (17x22,500)	Ordinary Use	High Referral
60	16	40	50
75	20	50	60
90	24	70	90
For ledger papers:			
90	24	60	70
120	32	90	110

3.8 Brightness. The brightness shall be not less than 75 percent, with the fluorescence component excluded, for white papers. The fluorescence contribution shall not exceed 2 percent.

3.9 Opacity. The minimum opacity for the several basis weights shall be as follows:

Basis Weight g/m^2	Basis Weight lbs (17x22,500)	Opacity %
For bond papers:		
60	16	80
75	20	83
90	24	85
For ledger papers:		
90	24	88
120	32	90

3.10 Sizes. The paper shall be furnished in the size, or sizes, specified at the time of purchase.

3.11 Colors. The paper shall be white, or colored, as specified at the time of purchase.

3.12 If the paper is to be used in a printing process, a stipulation that the paper shall be suitable for this purpose shall be included in the requirements.

3.13 Sampling shall be made according to one of the methods mentioned in section 4. The lot sample shall consist of no fewer than 10 test units with respect to requirements for weight per unit area, thickness, folding endurance, tearing resistance, and brightness.

4. METHODS OF TESTING

The properties enumerated in this specification shall be determined in accordance with the following ASTM or TAPPI methods:

Method	Number TAPPI	Number ASTM
Fiber analysis	T 401	D 1030
Acidity (pH)	T 435	D 778
Weight per unit area	T 410	D 646
Thickness	T 411	D 645
Folding endurance	T 511	D 2176
Tearing resistance	T 414	D 689
Ash content	T 413	D 586
Brightness	T 452	D 985
Sampling	T 400	D 585
Moisture	T 412	D 1348

Carbonate content - There is no standard TAPPI or ASTM method for the determination of carbonate in paper. A procedure is given in the appendix to this specification.

Fluorescence — Testing Standards, Joint Committee on Printing

APPENDIXES

A1. DISCUSSION

As there are many variables in the manufacture of paper and in the use and storage of records, it is impossible to place definitive values on the number of years that various categories of records will endure. It has been established that both natural and accelerated aging are functions of pH. The following information may be used as a guide:

Grade A papers. Machine-made papers with an alkaline filler have existed, apparently with little change, for at least 70 years. Hand-made papers containing an alkaline filler have survived for almost 400 years. Acid papers have survived this long, but their condition is, comparatively speaking, not as good.

Grade B papers. The probable longevity of these papers should lie somewhere between Grade A and Grade C papers.

Grade C papers. The relative condition of paper in old books and documents has been correlated with pH. Manifold papers in U.S. Government files with pH values as low as 4.2 have survived almost 50 years, and physical properties appear to be a function of pH. Therefore, a minimum pH of 5.5 should indicate longevity equal to or greater than 50 years.

Papers containing cotton and/or linen are considered by many people to be more durable than wood pulp papers. As both rag and wood pulp papers may cover a wide spectrum of permanence and durability, generalizations are not possible.

This specification is based on pH requirements. If more information is developed, it would be desirable for the specification to include an accelerated aging method.

No specification for erasing properties is included because no single method appears to be suitable for all situations. As erasing quality may be very important, it is suggested that this property be a subject of negotiation between the seller and the purchasing agent. A simple criterion might be agreed upon--e.g., that writing with aqueous ink on an erased area must not show visible feathering--or perhaps a more sophisticated procedure such as that described in TAPPI Method T 478.

A2. DETERMINATION OF CARBONATE CONTENT OF PAPER

A2.1 Qualitative

Place about 0.5 g of paper in a test tube of any convenient size. Cover to a depth of about 1 cm with 6 N HCl. A gentle continuous effervescence (not to be confused with initial desorption of gases from the surface of the paper) indicate the presence of carbonate.

A2.2 Quantitative

Weigh out about 1 gram of paper to the nearest milligram, making a correction for the moisture content[1], and place in about 25 ml of water in a 125 ml Erlenmeyer flask. Pipette 20 ml[2] of standardized 0.1 N HCl into the flask, heat to boiling, and boil for about 1 min. Add 3 drops of aqueous methyl red. Cool to room temperature and titrate to the first lemon yellow with standardized 0.1 N NaOH.

If a trace of pink indicator remains adsorbed on the surface of the paper, boil briefly to desorb the pink color. Usually a further drop of NaOH will restore the lemon yellow to the solution.

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[1]The specimen may be dried and weighed, or a separate portion may be used for moisture determination.

[2]For a 1 gram specimen, this is sufficient to neutralize the carbonate in a paper containing about 10 percent carbonate.

Calculate the carbonate content of the paper as calcium carbonate using the following formula:

$$CaCO_3,\ \% = \frac{(\text{ml} \times \underline{N})_{HCl} - (\text{ml} \times \underline{N})_{NaOH} \times 0.050 \times 100}{\text{wt. of specimen, grams}}$$

where 0.050 is the milliequivalent weight of $CaCO_3$. Duplicate determinations should agree within 0.3 percent calcium carbonate.

Table 1. Experimental test data for bond papers having a nominal weight of 16 pounds (17 x 22, 500).

Code No.	Rag Content	Thickness	Weight (17x22,500)		Opacity	Brightness MD	Brightness CD	Fold, MIT, 1 kg MD	Fold, MIT, 1 kg CD	Burst	Internal Tear MD	Internal Tear CD	pH		Special Attribute
	(%)	(in)	(lbs)	(g/m^2)	(%)	(%)	(%)	(double folds)		(pts)	(g)	(g)	(cold)	(hot)	
201	100	.0037	16.6	62.5	81	83	84	1100	970	37	55	52	6.0	5.2	high referral
202	100	.0032	15.7	59.2	75	76	77	1200	1000	34	56	50	5.4	5.9	high referral
203	100	.0033	16.2	61.1	74	83	84	1230	740	32	54	52	5.7	5.1	high referral
204	100	.0037	16.4	61.7	80	93	93	790	440	34	56	55	7.6	7.8	high referral
205	75	.0038	16.1	60.5	80	89	89	270	100	28	37	43	6.2	5.5	
206	50	.0038	16.5	62.0	87	82	83	400	200	28	53	49	6.2	5.3	
207	50	.0037	15.5	58.6	78	87	87	410	110	31	40	45	6.6	5.9	
208	25	.0036	15.2	57.3	77	78	79	400	280	31	47	43	6.5	5.5	
209	25	.0036	16.5	62.0	84	49	50	470	370	35	51	55	5.8	4.8	
210	25	.0037	16.0	60.4	79	87	87	350	140	31	38	43	6.6	6.1	
211	CW[1]	.0037	16.2	60.9	83	88	89	110	50	24	45	52	5.0	4.5	
212	CW[1]	.0035	15.9	59.9	78	82	84	84	74	22	43	44	5.7	5.0	
213	CW[1]	.0036	16.0	60.3	83	87	89	80	20	18	31	37	5.8	5.4	
214	CW[1]	.0035	16.3	61.6	82	83	85	75	46	16	47	52	5.6	4.7	
215	CW[1]	.0036	17.2	64.9	84	88	89	133	67	23	39	43	5.5	4.8	

[1]Chemical wood.

Table 2. Experimental test data for bond papers having a nominal weight of 20 pounds (17 x 22, 500).

Code No.	Rag Content	Thickness	Weight (17x22,500)		Opacity	Brightness		Fold, MIT, 1 kg		Burst	Internal Tear		pH		Special Attribute
						MD	CD	MD	CD		MD	CD			
	(%)	(in)	(lbs)	(g/m^2)	(%)	(%)	(%)	(double folds)		(pts)	(g)	(g)	(cold)	(hot)	
216	100	.0042	20.7	78.0	80	76	76	1100	580	44	71	84	5.6	4.8	high referral
217	100	.0044	21.0	79.0	80	82	84	1000	650	48	90	82	5.4	4.7	"
218	100	.0046	20.4	76.7	85	83	84	270	220	38	69	64	4.9	4.5	
219	100	.0041	20.0	75.4	~~83~~	~~89~~	~~90~~	~~1000~~	~~500~~	~~42~~	~~61~~	~~67~~	~~8.8~~	8.3	"
220	100	.0039	20.3	76.6	92	86	86	630	220	38	64	72	5.2	4.7	
221	75	.0046	20.1	75.7	80	89	89	200	100	33	51	55	6.1	5.9	
222	50	.0045	20.2	76.1	81	85	85	650	340	37	54	62	5.2	4.6	
223	50	.0046	19.5	73.3	88	89	90	190	90	28	72	78	5.7	5.2	
224	50	.0050	20.7	78.0	90	90	91	170	51	31	58	68	5.3	4.6	
225	50	.0049	20.2	76.2	84	88	88	420	180	37	63	73	6.8	6.3	
226	25	.0045	19.7	74.3	81	80	81	310	170	39	57	64	6.6	5.6	
227	25	.0048	20.1	75.9	87	79	81	270	63	32	57	67	6.1	5.2	
228	25	.0049	20.3	76.4	86	90	90	140	70	28	63	67	5.9	5.9	
229	25	.0045	19.7	74.3	84	89	90	130	44	32	57	67	6.3	5.4	
230	CW[1]	.0045	19.5	73.3	88	80	80	44	20	24	46	51	5.6	4.9	
231	CW[1]	.0047	20.1	75.9	88	88	88	43	19	23	60	65	5.3	4.7	
232	CW[1]	.0045	20.2	76.2	86	84	86	100	38	27	65	79	5.8	5.2	
233	CW[1]	.0041	21.0	79.0	91	80	81	180	160	31	69	68	8.6	9.5	
234	CW[1]	.0042	19.8	74.6	88	89	90	54	39	23	60	58	5.6	4.9	
235	CW[1]	.0042	19.7	74.4	88	80	81	28	16	21	51	50	5.7	5.1	
236	CW[1]	.0043	20.0	73.8	86	84	85	180	65	33	59	67	6.0	5.3	
237	CW[1]	.0047	19.6	75.8	89	87	87	72	24	29	55	59	5.4	4.8	
238	CW[1]	.0047	20.5	77.4	86	88	89	360	110	36	58	68	7.3	7.2	

[1]Chemical wood.

Table 3. Experimental test data for bond papers having a nominal weight of 24 pounds (17 x 22, 500).

Code No.	Rag Content	Thickness	Weight (17x22,500)		Opacity	Brightness MD	Brightness CD	Fold, MIT, 1 kg MD	Fold, MIT, 1 kg CD	Burst	Internal Tear MD	Internal Tear CD	pH		Special Attribute
	(%)	(in)	(lbs)	(g/m²)	(%)	(%)	(%)	(double folds)		(pts)	(g)	(g)	(cold)	(hot)	
239	100	.0050	24.7	93.1	85	75	76	1100	540	51	99	107	5.5	4.8	high referral
240	100	.0050	24.9	94.0	82	83	84	900	550	49	90	89	5.3	4.9	"
241	100	.0050	24.5	92.2	81	74	75	1600	640	58	91	106	4.8	4.6	"
242	100	.0048	25.7	96.7	83	83	84	770	180	46	87	100	5.3	4.9	
243	100	.0054	24.2	91.3	78	80	81	1600	700	46	94	106	5.4	4.8	"
244	100	.0060	25.2	95.1	86	80	81	59	35	28	68	72	4.7	4.3	
245	100	.0058	25.6	96.4	85	80	81	67	41	36	73	83	5.5	4.6	
246	100	.0055	24.6	92.8	90	84	85	170	140	44	89	81	4.8	4.5	
247	100	.0050	23.6	88.8	85	91	92	910	450	53	87	93	8.3	8.3	"
248	100	.0052	24.1	90.9	92	80	80	410	280	45	105	100	5.6	4.9	
249	75	.0059	24.9	94.0	87	90	91	340	88	44	84	100	6.1	5.6	
250	50	.0052	23.5	88.7	86	88	89	260	89	40	74	83	4.9	4.5	
251	50	.0055	23.9	90.1	87	88	88	300	140	42	70	76	6.3	6.1	
252	25	.0053	23.5	88.4	84	69	71	100	35	30	68	78	5.2	4.4	
253	25	.0052	22.4	84.4	85	79	81	61	19	27	59	72	5.9	4.7	
254	25	.0057	23.6	88.9	86	90	91	180	45	34	76	83	5.8	4.6	
255	25	.0056	24.4	92.0	87	79	81	70	23	30	76	80	5.8	4.8	
256	25	.0056	25.8	97.1	89	87	88	100	35	39	68	77	5.6	5.4	
257	25	.0052	24.2	91.0	90	88	89	103	40	30	70	81	5.7	5.1	
258	CW[1]	.0052	22.6	84.9	90	88	89	100	40	30	60	74	4.9	4.4	
259	CW[1]	.0051	25.1	94.6	92	80	81	240	66	37	82	88	8.7	8.8	

[1]Chemical wood.

Table 4. Experimental test data for ledger papers having a nominal weight of 24 pounds (17 x 22, 500).

Code No.	Rag Content	Thickness	Weight (17x22,500)		Opacity	Brightness MD	Brightness CD	Fold, MIT, 1 kg MD	Fold, MIT, 1 kg CD	Burst	Internal Tear MD	Internal Tear CD	pH		Special Attribute
	(%)	(in)	(lbs)	(g/m²)	(%)	(%)	(%)	(double folds)		(pts)	(g)	(g)	(cold)	(hot)	
260	100	.0042	23.7	89.3	94	79	80	860	760	48	68	62	6.3	5.7	High referral[1]
261	100	.0043	24.7	92.9	94	91	92	730	240	46	68	71	8.5	8.5	
262	100	.0045	24.0	90.3	86	81	83	350	210	44	76	86	5.7	4.9	high referral[2]
263	50	.0048	24.2	91.1	86	76	77	310	93	36	71	78	5.3	4.7	
264	50	.0045	23.9	90.2	86	81	82	180	77	36	66	72	5.7	5.1	
265	25	.0043	22.7	85.5	87	75	77	380	340	44	74	76	6.5	5.8	
266	CW[3]	.0047	24.0	90.5	88	75	78	180	27	31	63	81	4.8	4.8	
267	CW[3]	.0048	24.9	94.0	89	87	88	92	81	38	76	74	4.9	4.5	
268	CW[3]	.0047	23.8	89.6	87	82	83	52	26	34	65	72	5.1	4.6	
269	CW[3]	.0046	24.5	92.3	90	84	84	42	31	27	67	65	5.5	4.6	
270	CW[3]	.0047	24.2	91.3	88	82	84	48	37	29	75	70	5.2	4.5	
271	CW[3]	.0046	25.4	95.6	90	82	83	72	28	36	60	68	4.8	4.3	
272	CW[3]	.0046	24.7	93.0	89	80	81	66	45	35	58	57	4.7	4.1	

[1]High referral with respect to folding endurance but not tearing resistance.
[2]High referral with respect to tearing resistance but not folding endurance.
[3]Chemical wood.

Table 5. Experimental test data for ledger papers having nominal weights of 32 and 44 pounds (17 x 22, 500).

Code No.	Rag Content	Thickness	Weight (17x22,500)		Opacity	Brightness MD	Brightness CD	Fold, MIT, 1 kg MD	Fold, MIT, 1 kg CD	Burst	Internal Tear MD	Internal Tear CD	pH		Special Attribute
	(%)	(in)	(lbs)	(g/m²)	(%)	(%)	(%)	(double folds)		(pts)	(g)	(g)	(cold)	(hot)	
273	100	.0055	33.2	125	96	82	83	510	230	59	115	124	6.1	5.1	
274	100	.0059	34.0	128	90	80	81	580	200	53	129	139	5.7	4.8	
275	50	.0060	32.9	124	93	83	84	120	74	44	109	115	5.1	4.5	
276	25	.0052	31.3	118	91	77	78	640	670	54	125	117	6.2	4.9	high referral
277	25	.0060	31.8	120	93	83	84	42	27	37	93	103	5.9	5.2	
278	CW[1]	.0058	32.6	123	96	75	76	84	41	45	89	97	5.6	5.0	
279	CW[1]	.0059	31.1	117	93	88	89	130	56	44	105	117	4.9	4.6	
280	CW[1]	.0059	32.6	123	94	83	84	23	18	35	97	101	5.1	4.6	
281	CW[1]	.0065	29.7	112	93	79	80	175	91	41	120	112	8.9	8.8	
282	CW[1]	.0062	32.6	123	94	84	86	41	26	33	107	114	5.5	4.7	
283	CW[1]	.0058	31.8	120	93	83	84	50	39	41	88	91	4.7	4.2	
284	CW[1]	.0061	33.2	125	93	82	83	59	33	47	87	93	4.8	4.5	
285	CW[1]	.0060	32.4	122	94	82	83	36	18	31	99	107	5.2	4.5	
286	100	.0069	43.5	164	98	80	80	460	240	72	74	76	6.8	6.2	
287	25	.0070	41.4	156	95	79	81	350	200	59	53	51	6.2	5.2	
288	CW[1]	.0078	45.1	170	98	77	78	130	120	57	194	187	5.7	4.9	

[1]Chemical wood.

Table 6. Experimental test data for parchment papers having nominal weights of 16, 20, 24, and 32 pounds (17 x 22, 500).

Code No.	Rag Content	Thickness	Weight (17x22,500)		Opacity	Brightness MD	Brightness CD	Fold, MIT, 1 kg MD	Fold, MIT, 1 kg CD	Burst	Internal Tear MD	Internal Tear CD	pH	
	(%)	(in)	(lbs)	(g/m^2)	(%)	(%)	(%)	(double folds)		(pts)	(g)	(g)	(cold)	(hot)
289	100	.0041	17.6	66.3	80	87	88	500	270	35	42	47	6.9	6.5
290	100	.0047	20.2	76.2	83	87	88	590	250	42	55	59	7.0	6.3
291	100	.0057	25.1	94.5	88	87	88	480	240	46	84	92	6.7	6.2
292	100	.0052	24.9	93.7	86	82	83	330	190	46	83	84	6.1	5.3
293	100	.0058	33.7	127	90	79	80	1900	1500	91	135	133	7.4	7.2

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Table 7. Summary of JCP numbers and specifications for GPO papers included in this study.

Code No.	JCP No.	Rag Content	Thickness	Weight (17x22,500)		Fold, MIT, 1 kg	Opacity	Burst	pH	Grade
		(%)	(in)	(lbs)	(g/m^2)	(double folds) Avg, 2 directions	(%)	(pts)	(hot)	
201	G-80	100	--	16	60	800		--	5.5	Bond
206	G-70	50	--	16	60	--	82	--	5.0	Bond
208	G-40	25	--	16	60	100	--	--	5.0	Bond
209	G-60	25	--	16	60	--	84	--	4.7	Bond, opacified
222	G-70	50	--	20	75	--	84	--	5.0	Bond
226	G-40	25	--	20	75	100	--	--	5.0	Bond
260	J-30	100	.0042	24	90	700	--	--	5.5	Ledger
265	J-20	25	.0042	24	90	85	--	--	5.0	Ledger
266	J-10	CW[1]	.0042	24	90	35	--	--	4.4	Ledger
273	J-30	100	.0054	32	120	700	--	--	5.5	Ledger
276	J-20	25	.0054	32	120	75	--	--	5.0	Ledger
278	J-10	CW[1]	.0054	32	120	40	--	--	4.4	Ledger
286	J-30	100	.0072	44	165	500	--	--	5.5	Ledger
287	J-20	25	.0072	44	165	75	--	--	5.0	Ledger
288	J-10	CW[1]	.0072	44	165	25	--	--	4.4	Ledger
293	H-10	100	--	32	120	800	--	--	5.5	Deed, parchment

[1]Chemical wood.

Table 8. Coefficients of least squares correlations in the comparison of the weight per unit area of bond and ledger papers with internal tearing resistance, bursting strength, folding endurance, and opacity.

Comparison	Coefficient of Correlation
Weight vs. Internal Tearing Resistance	0.77
Weight vs. Bursting Strength	0.66
Weight vs. Folding Endurance	-0.05
Weight vs. Opacity	0.76

Table 9. Summary of average folding endurance, tearing resistance, and bursting strength of bond papers of different basis weights and rag content.

Rag Content	Basis Weight	MIT Folding Endurance, 1 kg	Tearing Resistance	Bursting Strength
(%)	(g/m^2)	(double folds)	(g)	(points)
100	60[1]	900	53	33
	75[2]	625	73	42
	90[3]	559	83	46
75	60	186	38	28
	75	148	51	33
	90	212	82	44
50	60	259	42	31
	75	183	66	32
	90	197	72	41
25	60	245	40	31
	75	119	58	31
	90	109	65	34
0	60	74	43	21
	75	86	61	27
	90	112	76	34

[1] 60 g/m^2 = 16 pounds (17 x 22, 500)

[2] 75 g/m^2 = 20 pounds (17 x 22, 500)

[3] 90 g/m^2 = 24 pounds (17 x 22, 500)

Table 10. Summary of average folding endurance, tearing resistance, and bursting strength of ledger papers of different basis weights and rag content.

Rag Content	Basis Weight	MIT Folding Endurance, 1 kg	Tearing Resistance	Bursting Strength
(%)	(g/m^2)	(double folds)	(g)	(points)
100	90[1]	382	70	45
	120[2]	387	113	53
50	90	166	73	36
	120	95	97	44
25	90	--	--	--
	120	35	78	37
0	90	59	68	33
	120	51	101	40

[1] 90 g/m^2 = 24 pounds (17 x 22, 500)

[2] 120 g/m^2 = 32 pounds (17 x 22, 500)

Table 11. Summary of average folding endurance, tearing resistance, and bursting strength of parchment papers of 100% rag content and different basis weights.

Rag Content	Basis Weight	MIT Folding Endurance, 1 kg	Tearing Resistance	Bursting Strength
(%)	(g/m^2)	(double folds)	(g)	(points)
100	60[1]	385	45	35
	75[2]	420	58	42
	90[3]	408	71	46

[1] 60 g/m^2 = 16 pounds (17 x 22, 500)

[2] 75 g/m^2 = 20 pounds (17 x 22, 500)

[3] 90 g/m^2 = 24 pounds (17 x 22, 500)

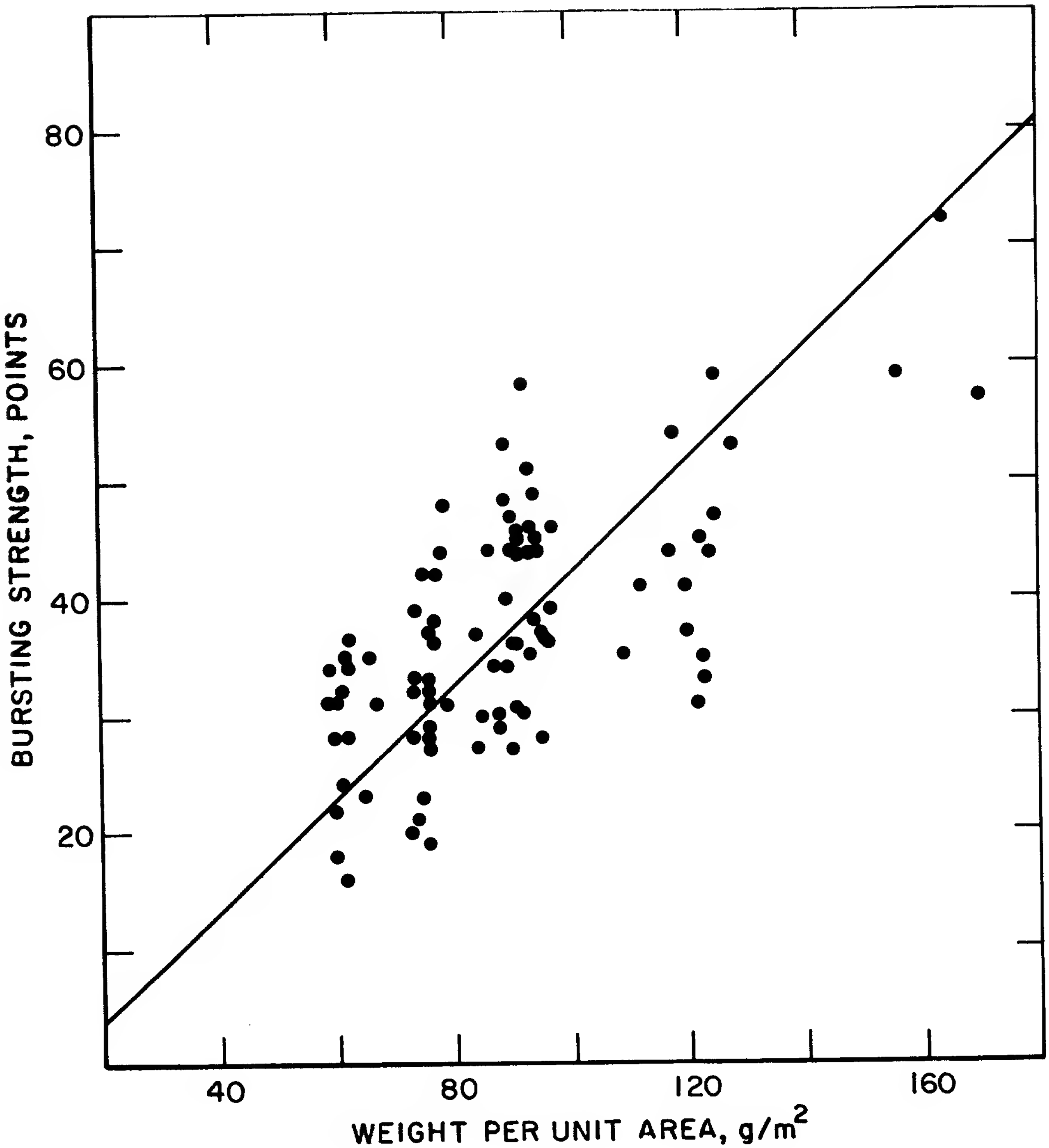

Fig. 1. Bursting strength of bond, ledger, and parchment papers as a function of weight per unit area.

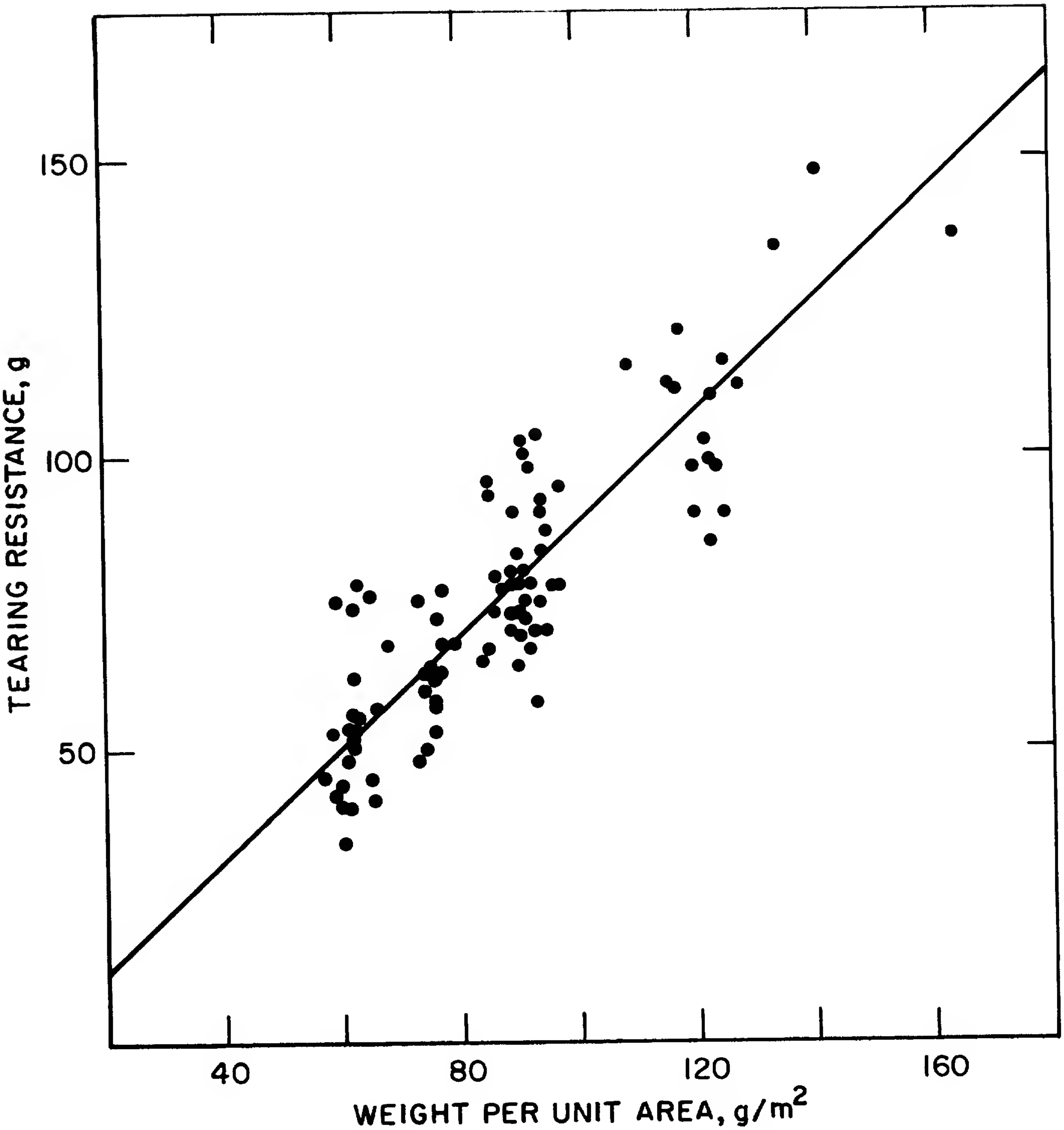

Fig. 2. Internal tearing resistance of bond, ledger, and parchment papers as a function of weight per unit area.

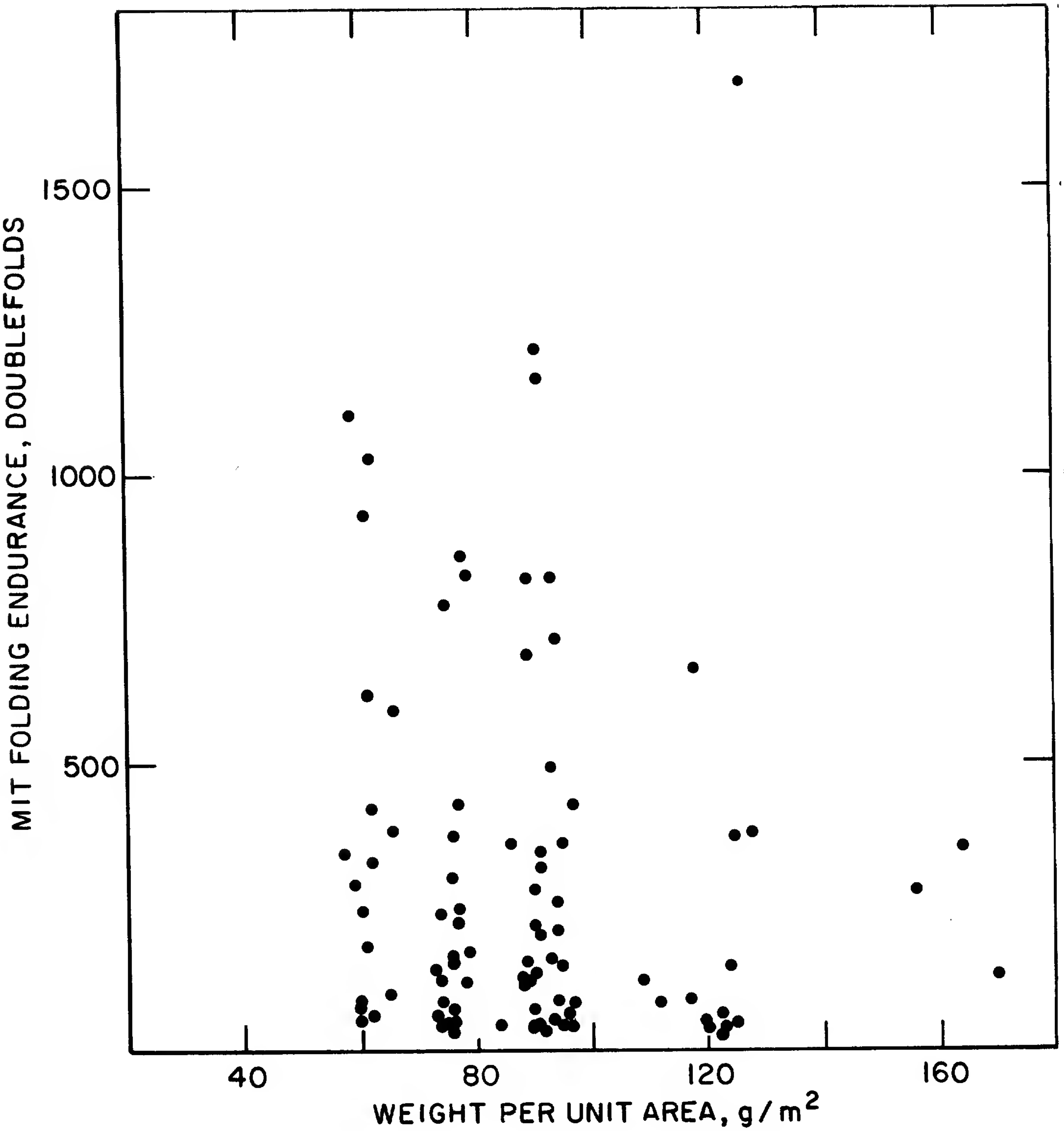

Fig. 3. Folding endurance of bond, ledger, and parchment papers as a function of weight per unit area.

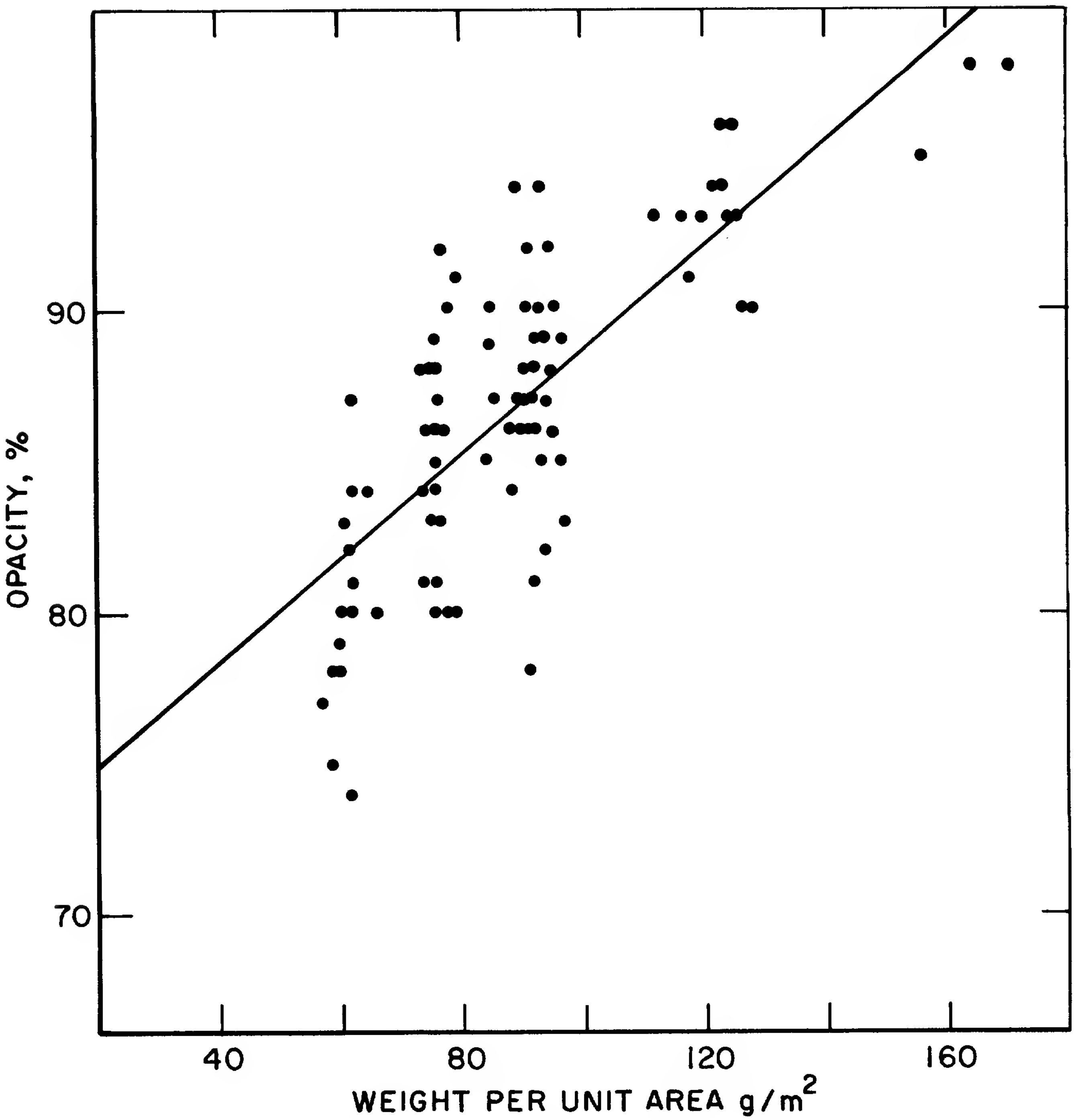

Fig. 4. Opacity of bond, ledger, and parchment papers as a function of weight per unit area.

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NATIONAL BUREAU OF STANDARDS REPORT

10 843

DEVELOPMENT OF SPECIFICATIONS FOR FILE FOLDERS FOR STORAGE OF PERMANENT RECORDS

Technical Report
to
National Archives and Records Service
General Services Administration

NBS

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Part of the Center for Radiation Research.
[3] Located at Boulder, Colorado 80302.

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NATIONAL BUREAU OF STANDARDS REPORT

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DEVELOPMENT OF SPECIFICATIONS FOR FILE FOLDERS FOR STORAGE OF PERMANENT RECORDS

E. J. Parks, R. L. Hebert, and G. H. Limparis
Paper Evaluation Section
Product Evaluation Technology Division
Institute for Applied Technology

Technical Report
to
National Archives and Records Service
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U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

DEVELOPMENT OF SPECIFICATIONS FOR FILE FOLDERS
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FOREWORD

In response to a request by National Archives and Records Service, the National Bureau of Standards is developing information on the variables associated with the stability of archival record materials, especially paper. Since the inception of the project, several U.S. Government agencies and the Society of American Archivists have joined in sponsorship of the project through National Archives and Records Service.

Although the present effort is directed toward paper, and especially the development of test methods that may be used in the preparation of specifications, other materials that will merit attention are quick copy reproductions from office copying machines, inks, typewriter ribbons, carbon paper, laminating film, mending tape and binding materials.

The objectives of this program are as follows: (1) the development of information on the stability of paper and other record materials, (2) the development of test methods for the evaluation of the stability of paper and other record materials, and (3) the development of specifications for these materials.

The principal need of the archivist and librarian is for specifications for the papers on which records are written. In order to achieve this, as much technical information as possible must be developed on the relative stability of various chemical structures that affect the physical properties of paper. Specifications should include tests that will predict permanence and that could be run in the usual control laboratory and should include an accelerated aging method.

In order to develop an accelerated aging method, it is necessary to age several papers in the laboratory, giving particular attention to variables such as the composition of the paper, temperature, relative humidity, open or closed aging system, and many others. Time does not permit the study of all possible variables but a study of selected variables allows one to make some generalizations about the parameters that are important in the stability of paper.

As the development of the information necessary to writing an accelerated aging method for estimating the relative stability of papers is long-range research, it is desirable to prepare interim specifications for various papers pending the availability of more complete data. The stability of papers can be predicted, on a relative basis, from the pH, or acidity values of the papers. The correlation between pH and stability is not a perfect one as stability depends, in addition to pH, on the chemical composition of the cellulose as well as additives that are introduced during the papermaking process.

Interim specifications, based on pH requirements, for manifold papers have been written and are going through channels in committee D-6, Paper, of the American Society for Testing and Materials. Work has been completed on specifications for bond and ledger papers and for file folders.

This report contains interim specifications for file folders and the data used in developing these specifications. The specifications are based on minimum pH requirements and minimum strength requirements. The latter are derived from data obtained from testing 28 samples of file folder stock obtained from commercial sources.

WILLIAM K. WILSON

1. INTRODUCTION

In order to provide a data base for writing interim specifications for file folders for permanent records, 28 file folder stocks were tested for thickness, weight per unit area, folding endurance, bursting strength, and internal tearing resistance. A high coefficient of correlation was found in the comparison of weight and thickness. Burst, fold, and tear usually increase with weight or thickness, but fold is not so closely related to weight as tear and burst. The pH values fall within a range of 4.3 to 5.5, except that one alkaline folder had a pH of 9.1.

Interim specifications for file folders are included in the appendix.

2. SAMPLES

Twenty-eight samples of paperboard suitable for file folders were tested. Of these, four were obtained from the Government Printing Office (GPO), and the remainder were obtained directly from the manufacturers.

The four obtained from GPO had been bought on specifications of the Congressional Joint Committee on Printing (JCP), and these samples included a postal card paper, two durable chemical wood boards, and a jute tagboard of exceptional strength and durability. The samples obtained directly from the manufacturers included materials described as tag wood, kraft, and hardwood folders. These are listed in order of increasing weight and thickness in Tables 1-4. Colors and styles are given in these tables, but fiber content of the directly obtained samples is not known.

The samples obtained from the Government Printing Office are identified in Table 5. Table 5 includes the JCP specifications pertaining to these samples.

3. TEST METHODS

The testing methods used are described in the collected "Standard and Suggested Methods" of TAPPI (Testing Methods and Recommended Practices, Technical Association of the Pulp and Paper Industry, 1 Dunwoody Park, Atlanta, Georgia 30341).

3.1 Thickness

Thickness was determined according to TAPPI T 411 and is reported in inches (in.) and millimeters (mm).

3.2 Weight per Unit Area

The weight per unit area was determined by TAPPI Method T 410 and is reported both in grams per square meter (g/m^2) and pounds per 500 sheets, 24 x 36 in. (24" x 36", 500).

3.3 Folding Endurance

Folding endurance was determined by TAPPI Method T 423, Part II, using clamps with jaws having sufficient clearance to accommodate file folder stock, which is considerably thicker than most papers. Folding endurance is reported in both cross and machine directions.

3.4 Bursting Strength

Bursting strength was determined on most of the samples by TAPPI Method T 403. Those having a bursting strength greater than 120 points were tested according to TAPPI Method T 807, using an instrument with a greater pressure range.

3.5 Internal Tearing Resistance

Tearing resistance was measured according to TAPPI Method T 414 and is reported for both cross and machine direction in grams (g).

3.6 pH

pH was determined by both hot and cold extraction by TAPPI Methods T 435 and T 309, respectively.

3.7 Number of Replicate Tests

pH determinations were performed in duplicate. All other tests were performed on at least ten specimens of every sample. The individual figures in Tables 1-4 represent averages of all of the results obtained on each sample.

4. RESULTS AND DISCUSSION

4.1 Results

The data are presented in Tables 1-4, in which the file folder stocks are listed in order of increasing thickness. The least squares slope given in Figure 1 indicates a direct relationship between weight per unit area and thickness. Figures 2 and 3 show that internal tearing resistance is closely related to weight and to thickness. Bursting strength and folding endurance, as indicated in Figures 4 and 5, are not as closely related to weight as internal tearing resistance. Table 6 presents the various coefficients of correlation.

4.2 Discussion

It is conventional practice to list the thicknesses of file folders rather than their weight per unit area. However, the high correlation between weight and thickness, indicated in Table 6 and in Figure 1, suggests that two parameters are nearly interchangeable. Although the interim specifications attached to this report refer principally to thickness, the correlation of both thickness and weight with strength parameters is discussed here.

Figures 2, 4, and 5 indicate that greater folding endurance, bursting strength, and tearing resistance accompany higher weights. Similar comparisons can be obtained if thickness is substituted for weight, as shown for tearing resistance in Figure 3. However, there is a great deal of variation due, probably, to composition variables. Bursting strength and fold are especially erratic. The plots shown in Figures 4 and 5 indicate that it would not be advisable to peg either bursting strength or folding endurance requirements to the basis weights (or thickness) of file folders.

All but five of the samples would pass a minimum average folding endurance of 300 in the machine and cross directions. This minimum should be required in the interim specifications. Practical experience should determine whether samples having a minimum average fold of 300 also meet usage requirements, and the specification can be revised in view of this experience. "High usage" folders with an average folding endurance above 1000 may be requested if hard usage is expected. In that case, the specification should include a minimum folding endurance of 500 in the weaker direction.

The data in Figures 2 and 3 suggest that requirements for internal tearing resistance could readily be based on either basis weights or thicknesses. Burst is much more erratic than tear and may be omitted from this specification.

Using the intercept and slope indicated in Figure 3, the minimum average tearing strength in the machine and cross directions for samples having a weight of 150 grams per square meter is 130 grams, and the tear requirement increases at the rate of 2.6 grams per gram of weight. The requirement based on thickness is 180 grams of tearing resistance for folders having a thickness of 8 mils, and an additional 54 grams per mil of additional thickness.

The composition of the commercial folders is not known. The JCP specifications mention various fiber furnishes: (1) chemical wood that is free from ground wood, (2) 50 percent hemp material with the remainder free from ground wood, (3) 100 percent chemical wood pulp, and (4) paper that is free from unbleached or ground wood pulp. Judging from this variety, the material going into folders could be quite variable. The physical properties depend to an important extent on composition. For example, JCP P-30, which is 50 percent hemp, has a specified minimum tear of 925 grams (total, both directions). Another, heavier sample of cardboard, JCP Q-70, has a specified minimum tear (total, both directions) of 530 grams.

The pH value is important for folders intended to contain permanent records. A folder of low pH may initiate the deterioration of papers stored inside its covers. It is suggested that folders having a pH of 5.5 or above should be specified when permanent records are to be stored. Sample 323, which is alkaline, would be satisfactory.

5. CONCLUSION

The data indicate that the internal tearing resistance of file folders is closely correlated with weights per unit area, which, in turn, is closely related to thicknesses. As file folders are generally sold according to thicknesses, invitations for bids could peg tear requirements to thicknesses or, alternately, to weights per unit area. Burst and fold are erratic. All of the folders tested showed a folding endurance higher than 300, but it is quite possible to obtain folding endurances of 2000 or 3000. Average folding endurances as high as 1000 (500 in the weaker direction) may be specified for high usage folders, but this should be considered exceptional.

For storage of permanent records, a pH of 5.5 or higher should be specified.

6. ACKNOWLEDGMENT

The assistance of manufacturers who supplied samples for evaluation and who, for obvious reasons, must remain unnamed, is gratefully acknowledged.

APPENDIX--
PROPOSED NEW STANDARD SPECIFICATIONS FOR FILE FOLDERS FOR PERMANENT RECORDS

1. SCOPE

This specification covers file folder stock used to prepare folders in which permanent or semi-permanent copies of records and documents are to be stored. Permanence has been shown to be at least an approximate function of pH, and two pH levels, reflecting two levels of permanence, are specified.

2. CLASSIFICATION

2.1 Grades. Two grades are specified. The only differences between the grades are the pH requirements and the type of filler or sizing to achieve this. For situations where the folders will be opened and closed frequently, the grade should be described as "high usage." A minimum average folding endurance of 1000 in the machine and cross directions (500 in the weaker direction) is required for this category, and the purchaser might wish to specify the proportions of chemical wood or hemp.

2.2 Grade A. File folder stock with alkaline filler. The stock shall contain an alkaline filler of calcium and/or magnesium carbonate. The minimum shall be 2 percent, calculated to calcium carbonate, based on the oven dry weight of the finished paper. The pH shall fall within the range 7.5-9.5, hot extraction.

2.3 Grade B. Folder stock with minimum pH value. The stock shall have a minimum pH of 5.5, hot extraction.

3. REQUIREMENTS

3.1 File Folder Stock. Free from ground wood pulp. The stock shall be unbleached or fully bleached wood pulp, with additions of hemp as specified at the time of purchase.

3.2 Acidity (pH). See 2.1.

3.3 Sizing. If a sizing requirement is necessary, the sizing shall be sufficient to prevent feathering when the paper is written on with aqueous inks.

3.4 Thickness. The average thickness in mils (0.001 inch) shall be 7.6-8.4, 9.0-10.0, 10.5-11.5, or 13.3-14.7 (.19-.21, .23-.25, .27-.29, or .34-.37 mm), but the variation of test unit averages within a shipment (or lot) shall be not more than 5 percent above or below the average value.

3.5 Folding Endurance, MIT double folds at 1 kg tension. For "high usage" folders, the value shall be not less than 500 in the weaker of the two directions. Otherwise, the folding endurance requirement shall be 300 for the average of two directions.

3.6 Tearing Resistance. The average in each direction shall be as follows:

Nominal Thickness (mm)	Tearing Resistance (gms)
0.20	180
.24	260
.28	340
.36	500

3.7 Ash Content. The ash content shall be no greater than 10 percent as measured by TAPPI procedure T413 ts-66.

3.8 Sizes. The paper shall be furnished in the size, or sizes, specified at the time of purchase.

3.9 Colors. The paper shall be white, or colored, as specified at the time of purchase.

3.10 If the paper is to be used in a printing process, a stipulation that the paper shall be suitable for this purpose shall be included in the requirements.

3.11 Sampling shall be made according to one of the methods mentioned in section 4. The lot sample shall consist of no fewer than 10 test units with respect to requirements for weight per unit area, thickness, folding endurance, tearing resistance, and brightness.

4. METHODS OF TESTING

The properties enumerated in this specification shall be determined in accordance with the following ASTM or TAPPI methods:

Method	Number TAPPI	Number ASTM
Fiber analysis	T 401	D 1030
Acidity (pH)	T 435	D 778
Thickness	T 411	D 645
Folding endurance	T 511	D 2176
Tearing resistance	T 414	D 689
Ash content	T 413	D 586
Sampling	T 400	D 585
Moisture	T 412	D 1348

Carbonate content - There is no standard TAPPI or ASTM method for the determination of carbonate in paper. A procedure is given in the appendix to this specification.

APPENDIXES

A1. DISCUSSION

As there are many variables in the manufacture of paper and in the use and storage of records, it is impossible to place definitive values on the number of years that various categories of records will endure. It has been established that both natural and accelerated aging are functions of pH. The following information may be used as a guide:

Alkaline papers. Machine-made papers with an alkaline filler have existed, apparently with little change, for at least 70 years. Hand-made papers containing an alkaline filler have survived for almost 400 years. Acid papers have survived this long, but their condition is, comparatively speaking, not as good.

Papers of minimum pH. The relative condition of paper in old books and documents has been correlated with pH. Manifold papers in U.S. Government files with pH values as low as 4.2 have survived almost 50 years, and physical properties appear to be a function of pH. Therefore, a minimum pH of 5.5 should indicate longevity equal to or greater than 50 years for such papers.

This specification is designed for file folder stock in which records are stored. Consequently, it is based on pH requirements similar to those for record papers. If more information is developed, it would be desirable for the specification to include an accelerated aging method.

A2. DETERMINATION OF CARBONATE CONTENT OF PAPER

A2.1 Qualitative

Place about 0.5 g of paper in a test tube of any convenient size. Cover to a depth of about 1 cm with 6 N HCl. A gentle continuous effervescence (not to be confused with initial desorption of gases from the surface of the paper) indicate the presence of carbonate.

A2.2 Quantitative

Weigh out about 1 gram of paper to the nearest milligram, making a correction for the moisture content[1], and place in about 25 ml of water in a 125 ml Erlenmeyer flask. Pipette 20 ml[2] of standardized 0.1 N HCl into the flask, heat to boiling, and boil for about 1 min. Add 3 drops of aqueous methyl red. Cool to room temperature and titrate to the first lemon yellow with standardized 0.1 N NaOH.

If a trace of pink indicator remains adsorbed on the surface of the paper, boil briefly to desorb the pink color. Usually a further drop of NaOH will restore the lemon yellow to the solution.

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[1]The specimen may be dried and weighed, or a separate portion may be used for moisture determination.

[2]For a 1 gram specimen, this is sufficient to neutralize the carbonate in a paper containing about 10 percent carbonate.

Calculate the carbonate content of the paper as calcium carbonate using the following formula:

$$CaCO_3,\ \% = \frac{(\text{ml} \times \underline{N})_{HCl} - (\text{ml} \times \underline{N})_{NaOH} \times 0.050 \times 100}{\text{wt. of specimen, grams}}$$

where 0.050 is the milliequivalent weight of $CaCO_3$. Duplicate determinations should agree within 0.3 percent calcium carbonate.

Table 1. Experimental test data for file folders having a nominal thickness of 8 mils.

Code No.	Composition, Color	Weight (24x36,500)		Thickness		Tearing Resistance MD	CD	Bursting Strength	Folding Endurance MIT, 1 kg MD	CD	pH	
		(lbs)	(g/m²)	(in)	(mm)	(g)	(g)	(pts)	(double	folds)	(cold	(hot)
310	tagboard, white	102	166	.0076	0.193	177	185	49	89	79	5.2	4.6
311	tagboard, manila	102	167	.0074	0.188	176	195	61	280	210	5.0	4.6
312	manila	113	185	.0081	0.206	223	221	67	400	610	5.6	5.1

Table 2. Experimental data for file folders having a nominal thickness of 9.5 mils.

Code No.	Composition, Color	Weight (24x36,500)		Thickness		Tearing Resistance MD	Tearing Resistance CD	Bursting Strength	Folding Endurance MIT, 1 kg MD	Folding Endurance MIT, 1 kg CD	pH	
		(lbs)	(g/m^2)	(in)	(mm)	(g)	(g)	(pts)	(double folds)		(cold	(hot)
313	postal card	116	189	.0094	0.239	214	227	73	160	210	6.0	5.5
314	tagboard, manila	127	207	.0095	0.241	230	273	56	470	79	5.2	4.7
315	tagboard, white	123	200	.0096	0.244	209	230	53	110	47	4.8	4.3
316	kraft, manila	131	214	.0096	0.244	368	357	78	600	980	5.1	4.8
317	tagboard, manila	131	214	.0096	0.244	308	263	78	580	640	5.2	4.5
318	manila	131	213	.0096	0.244	325	306	62	550	560	4.9	4.4
319	manila	132	216	.0097	0.246	313	291	87	710	1000	6.0	5.2
320	buff	135	220	.0098	0.249	348	427	127	3700	1500	5.4	4.6
321	chem. wood tagboard, manila	140	228	.0098	0.249	261	372	117	1700	360	5.9	5.2
322	chem. wood tagboard	141	229	.0101	0.257	238	381	106	1800	75	4.7	4.3

Table 3. Experimental test data for file folders having a nominal thickness of 11 mils.

Code No.	Composition, Color	Weight (24x36,500)		Thickness		Tearing Resistance MD	Tearing Resistance CD	Bursting Strength	Folding Endurance MIT, 1 kg MD	Folding Endurance MIT, 1 kg CD	pH	
		(lbs)	(g/m^2)	(in)	(mm)	(g)	(g)	(pts)	(double folds)		(cold	(hot)
323	manila	142	231	.0104	0.264	362	344	103	1[illegible]00	1300	8.2	9.1
324	manila	151	247	.0110	0.279	387	359	89	590	910	5.9	5.3
325	gray hardwood	154	251	.0110	0.279	414	523	122	2800	780	5.0	4.4
326	ivory	153	249	.0110	0.279	318	456	126	1300	600	6.1	5.6
327	manila	150	244	.0116	0.294	336	356	67	580	160	5.2	4.6
328	manila	150	244	.0112	0.284	325	320	84	640	430	5.4	4.7
329	ivory	147	239	.0112	0.284	320	461	129	1500	700	5.6	5.0
330	buff	151	246	.0113	0.287	388	437	127	2900	1800	5.9	5.0
331	manila	151	247	.0115	0.292	422	466	90	1400	860	4.9	4.4
332	kraft	151	247	.0116	0.295	340	475	124	1400	660	5.3	5.0

Table 4. Experimental test data for file folders having a nominal thickness of 14 mils.

Code No.	Composition, Color	Weight (24x36,500)		Thickness		Tearing Resistance MD	CD	Bursting Strength	Folding Endurance MIT, 1 kg MD	CD	pH	
		(lbs)	(g/m²)	(in)	(mm)	(g)	(g)	(pts)	(double	folds)	(cold	(hot)
333	tagboard, manila	174	284	.0132	0.335	380	390	96	640	500	5.4	4.7
334	buff	179	292	.0139	0.353	557	530	124	3000	2700	5.9	4.8
335	manila	199	325	.0143	0.363	531	484	98	1000	1360	5.1	4.8
336	jute tag	199	325	.0147	0.373	560	790	150	4500	2700	5.7	4.9
337	--	189	307	.0150	0.381	568	566	106	1700	1400	4.8	4.3

Table 5. Summary of JCP numbers and specifications for GPO folders included in this study.

Code No.	JCP No.	Type and Composition	Weight (24x36,500) (lbs)	Thickness (in)	Bursting Strength (points)	Tearing Resistance[1] (g)	pH (hot)
313	Q-60	U.S. Postal card	120	.009	--	--	4.4
321	P-10	chem. wood, manila tag-board	140	--	100	--	--
322	Q-50	chem. wood, tagboard	135	.0098	80	520	--
336	P-30	jute tag	190	--	--	925	4.8

[1] Total of two directions.

Table 6. Coefficients of least squares correlations in the comparison of file folder weights and thicknesses with each other and with internal tearing resistance, bursting strength, and folding endurance.

Comparison	Coefficient of Correlation
Thickness vs. weight per unit area	0.98
Thickness vs. internal tearing resistance	0.92
Thickness vs. bursting strength	0.62
Thickness vs. folding endurance	0.58
Weight vs. internal tearing resistance	0.93
Weight vs. bursting strength	0.65
Weight vs. folding endurance	0.62

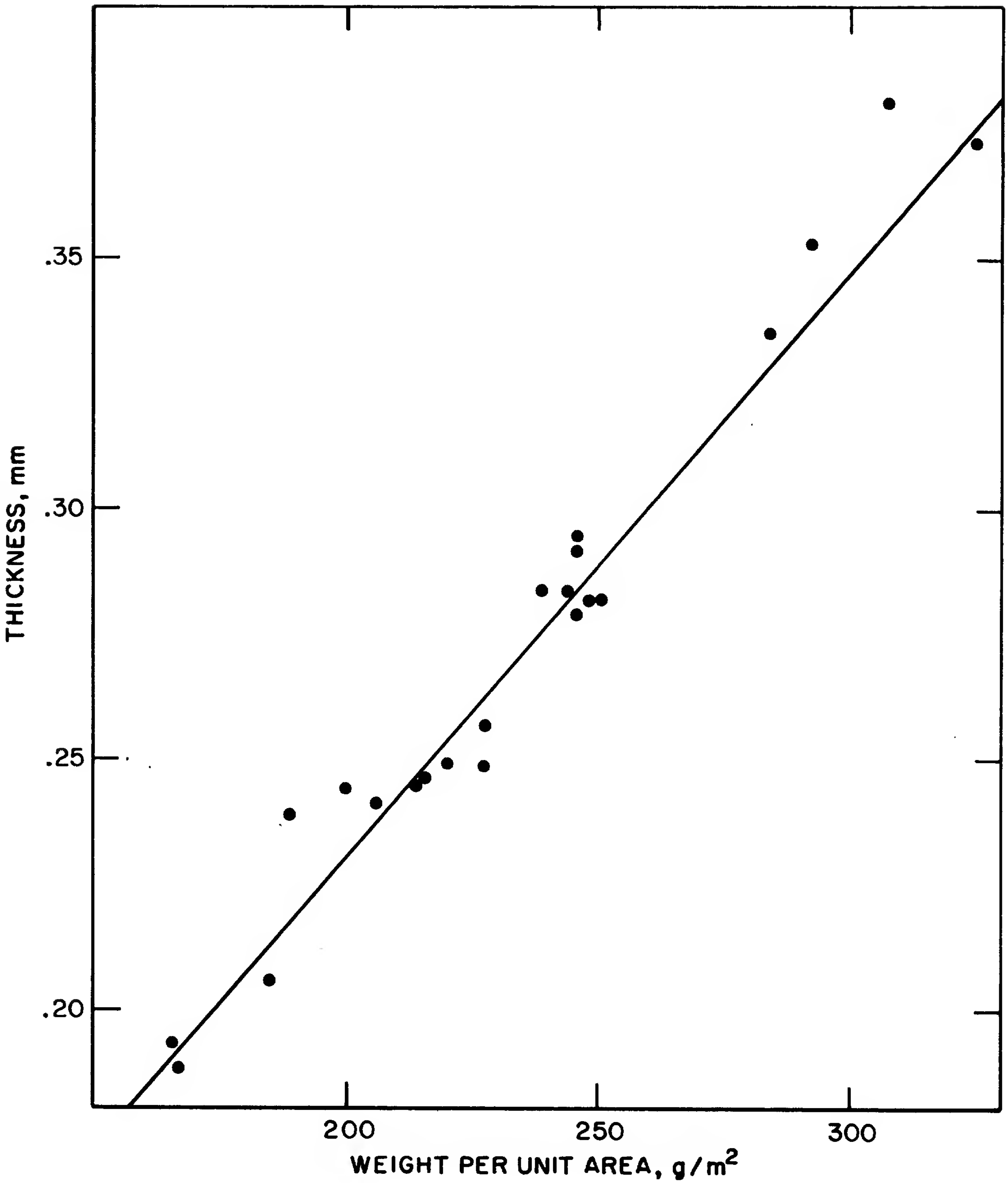

Fig. 1. Thickness of file folders as a function of basis weight.

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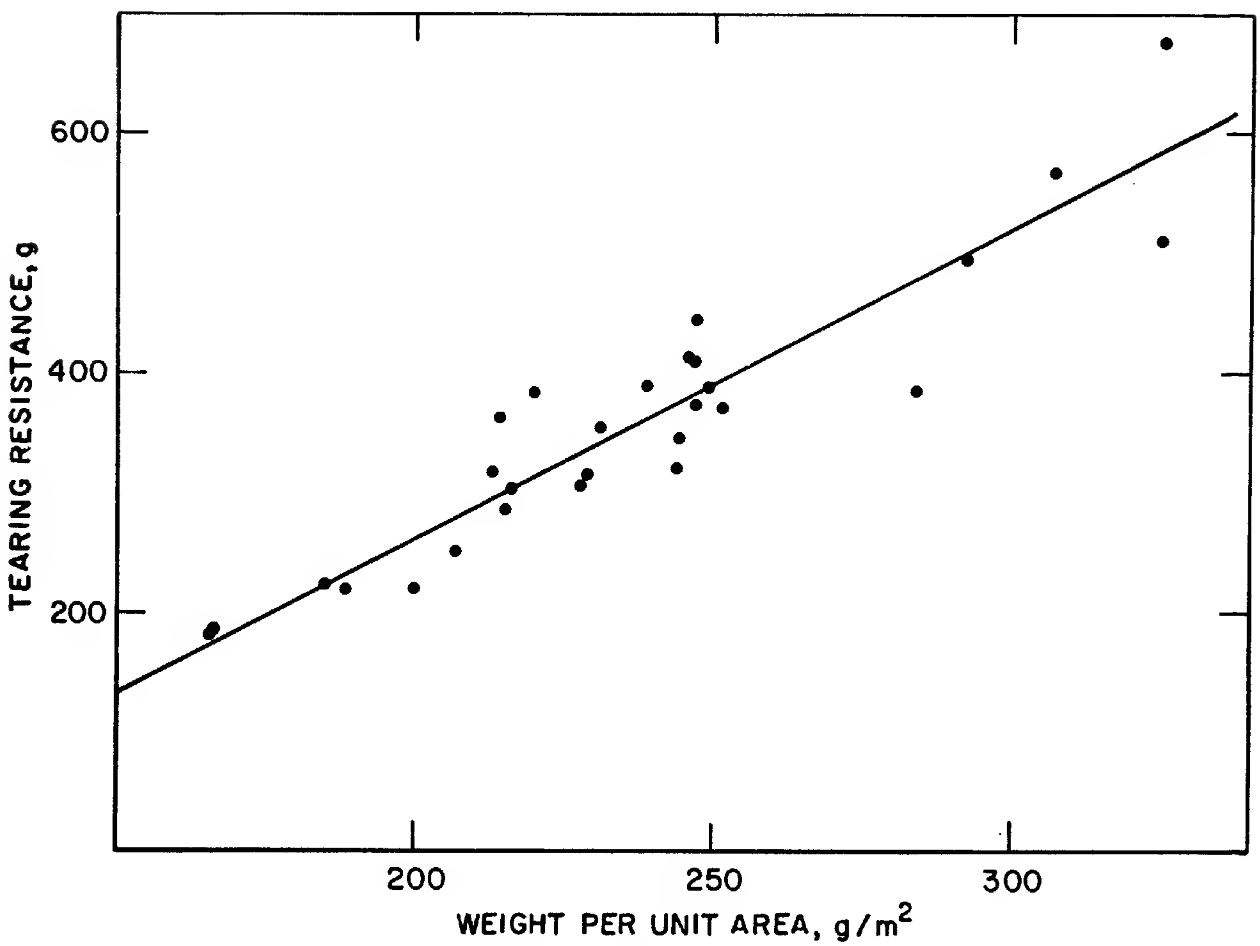

Fig. 2. Internal tearing resistance (g) of file folders as a function of weight per unit area.

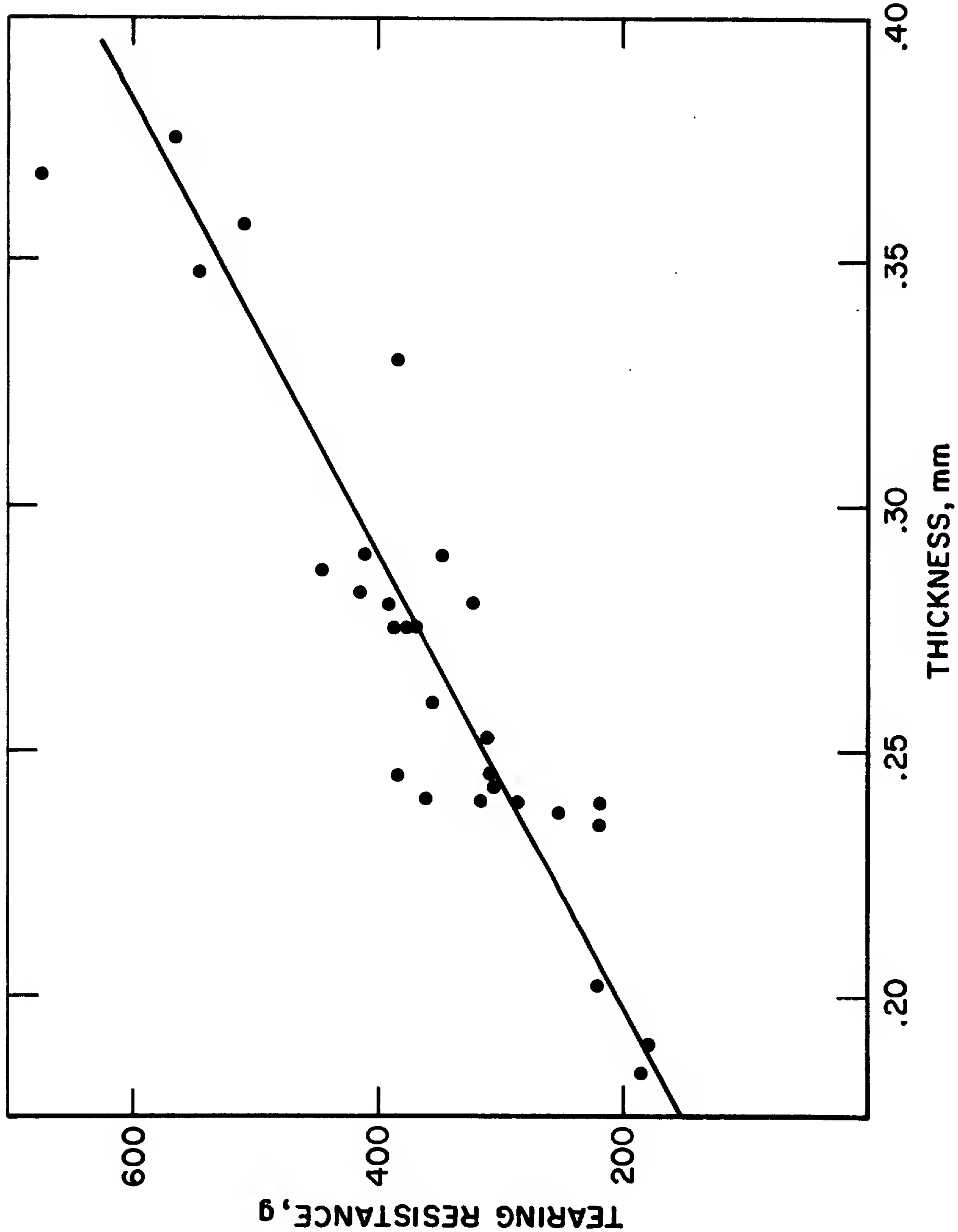

Fig. 3. Internal tearing resistance (g) of file folders as a function of thickness.

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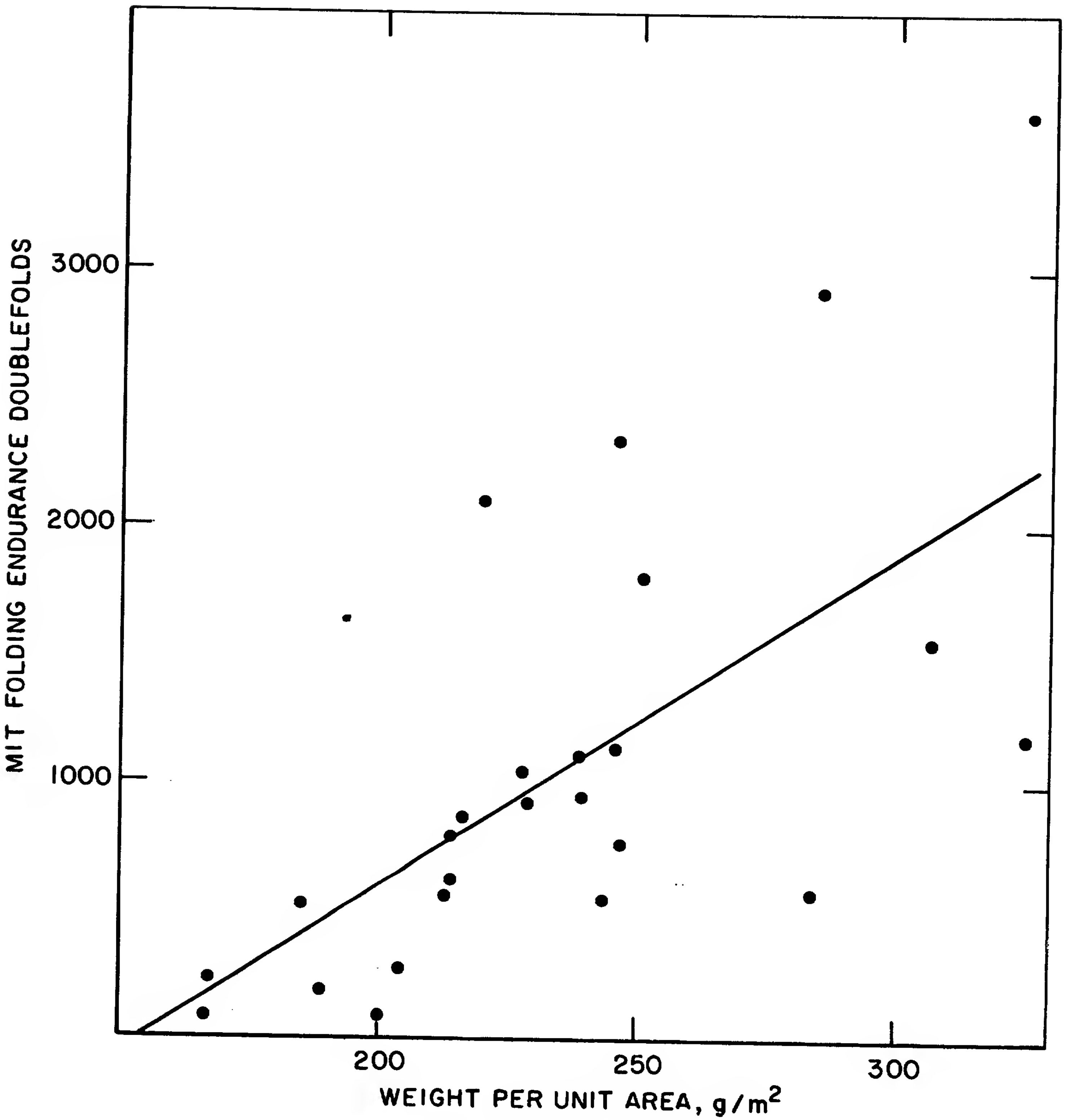

Fig. 4. MIT folding endurance (1 kg, double folds) of file folders as a function of weight per unit area.

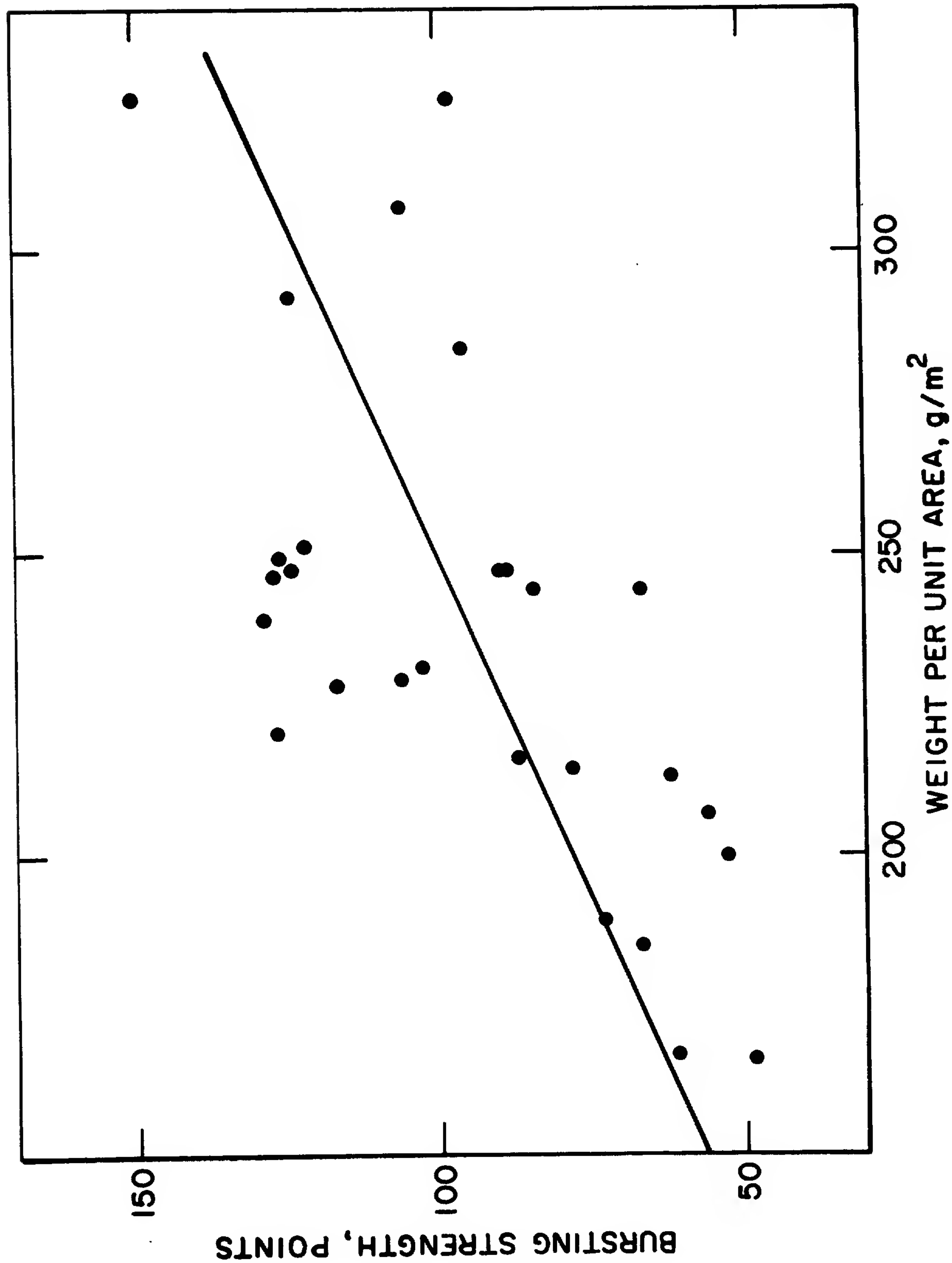

Fig. 5. Bursting strength (points) of file folders as a function of weight per unit area.

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